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NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)

Pancreatic Adenocarcinoma

Version 2.2016

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Pancreatic Adenocarcinoma

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Clinical Trials: NCCN believes that the best management for any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

To find clinical trials online at NCCN Member Institutions, [click here: nccn.org/clinical_trials/physician.html](#).

NCCN Categories of Evidence and Consensus: All recommendations are category 2A unless otherwise specified.

See [NCCN Categories of Evidence and Consensus](#).

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NCCN Guidelines Version 2.2016 Updates

Pancreatic Adenocarcinoma

Updates in Version 2.2016 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 1.2016 include:

MS-1

- The Discussion section has been updated to reflect the changes in the algorithm.

Updates in Version 1.2016 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 2.2015 include:

PANC-1

- Under workup, “Obtain family history” has been added with the following footnote: “If pancreatic cancer is diagnosed, consider referral for genetic counseling for patients who are young or who have a family history of cancer.”
- “Chest imaging” has been changed to “Chest CT (preferred) or x-ray.”

PANC-3

- Footnote “i” has been revised: “*For patients with tumors that are clearly resectable and who do not have high-risk features, neoadjuvant therapy is only recommended in a clinical trial. For patients with high-risk features (ie, very highly elevated CA 19-9, large primary tumors, large regional lymph nodes, excessive weight loss, extreme pain), neoadjuvant chemotherapy may be considered, which requires biopsy confirmation of adenocarcinoma (see PANC-4). Acceptable neoadjuvant regimens include FOLFIRINOX or gemcitabine + albumin-bound paclitaxel. Subsequent chemoradiation is sometimes included. Most NCCN Member Institutions prefer neoadjuvant therapy at a high-volume center.*” ~~In selected patients who appear technically resectable but have poor prognostic features (ie, very highly elevated CA 19-9, large primary tumors, large regional lymph nodes, excessive weight loss, or extreme pain) consider neoadjuvant therapy (clinical trial preferred), which requires biopsy confirmation of adenocarcinoma (see PANC-4). For patients with biliary obstruction, durable biliary decompression is required.~~

PANC-4

- “Baseline CA 19-9” has been added to the initial workup, and “Post-treatment CA 19-9” has been added to the workup following neoadjuvant therapy.
- After neoadjuvant therapy, the first bullet has been revised and split into two bullets: “*Pancreatic protocol CT or MRI (abdomen and pelvis); and, Chest imaging CT (preferred) or x-ray.*”
- If unresectable at surgery, the options for patients with jaundice have been revised: “~~Self-expanding metal stent or~~ *Consider surgical biliary bypass ± gastrojejunostomy...*”

PANC-5

- Former algorithm for “Borderline Resectable Disease, Planned Resection” has been removed.
- New algorithm for “Borderline Resectable, No Metastases, Cancer Not Confirmed” has been added.

PANC-6

- The second adjuvant therapy option has been revised: “*Systemic gemcitabine or 5-FU/leucovorin or continuous infusion 5-FU before ~~or~~ and after chemoradiation...*”
- The frequency of surveillance after two years has been changed from “annually” to “every 6–12 mo.”
- The following has been added to footnote “o”: “The adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.”

PANC-8

- The second-line therapy options have been separated into recommendations for those “previously treated with gemcitabine-based therapy” or “previously treated with fluoropyrimidine-based therapy.” (Also on PANC-9)
- Footnote “v” has been added: “FOLFIRINOX should be limited to those with ECOG 0-1. Gemcitabine + albumin-bound paclitaxel is reasonable for patients with KPS ≥70.” (Also on PANC-9)

PANC-9

- The following second-line therapy option has been added for patients with metastatic disease previously treated with gemcitabine-based therapy: “5-FU + leucovorin + liposomal irinotecan (category 1).” (Also on PANC-G, 1 of 3)

[Continued on next page](#)

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NCCN Guidelines Version 2.2016 Updates

Pancreatic Adenocarcinoma

Updates in Version 1.2016 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 2.2015 include:

[PANC-A](#)

- The following reference has been added: Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. *Radiology* 2014 Jan; 270(1):248-260. (Also on PANC-B)

[PANC-A \(2 of 8\)](#)

- The following has been added to #8: “Intraoperative ultrasound can be used as a diagnostic adjunct during staging laparoscopy.”
- #10 has been added: “For locally advanced/metastatic disease, the panel recommends serial CT (routine single portal venous phase or dedicated pancreatic protocol if surgery is still contemplated) or MRI of known sites of disease to determine therapeutic benefit. It is recognized that patients can demonstrate progressive disease clinically without objective radiologic evidence of disease progression.”

[PANC-A \(5 of 8\)](#)

- The Pancreatic Cancer Radiology Reporting Template has been included and adapted from:
 - ▶ Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. *Radiology* 2014 Jan; 270(1):248-260.

[PANC-C](#)

- Under distal pancreatectomy, the following bullet has been removed: “Utilization of radical resection is associated with an increase in blood loss, transfusion requirements, operating time, length of stay, and whether morbidity/mortality remains acceptable.”

[PANC-D \(2 of 4\)](#)

- Under histologic sectioning, the last sub-bullet has been revised: “*Consider* frozen section analysis of the pancreatic neck and bile duct ~~is recommended.~~”

[PANC-E](#)

- The third bullet has been revised: “Severe tumor-associated abdominal pain *that is unresponsive to optimal, around-the-clock narcotic administration, or if patient experiences undesirable narcotic associated side effects (See NCCN Guidelines for Adult Cancer Pain).*”
- Footnote “c” has been added: “A randomized trial examining the effects of prophylactic low-molecular-weight heparin showed a decrease in VTE but no effect on survival. (Pelzer U, Opitz B, Deuschinoff G, et al. Efficacy of prophylactic low-molecular weight heparin for ambulatory patients with advanced pancreatic cancer: Outcomes from the CONKO-004 trial. *J Clin Oncol* 2015;33:2028–2034.)”

[PANC-F \(2 of 6\)](#)

- The following adjuvant therapy option has been removed: “Upfront fluoropyrimidine- (CI 5-FU or capecitabine) or gemcitabine-based chemoradiation followed by maintenance 5-FU or gemcitabine.”
- Footnote “b” has been added: “Adjuvant options listed apply only to patients who did not receive prior neoadjuvant therapy. For those who received prior neoadjuvant therapy, the adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.”

[PANC-G \(1 of 3\)](#)

- After gemcitabine + cisplatin, the text in parenthesis has been revised: “*Can be considered as an alternative to FOLFIRINOX especially for in patients with possible hereditary cancers involving DNA repair mutations.*”

[PANC-G \(2 of 3\)](#)

- The following bullet has been added: “Recommended adjuvant therapy options apply to patients who did not receive prior neoadjuvant therapy. For those who received prior neoadjuvant therapy, the adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.”

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Clinical Trials: NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

INTRODUCTION

Decisions about diagnostic management and resectability should involve multidisciplinary consultation at a high-volume center with use of appropriate imaging studies.

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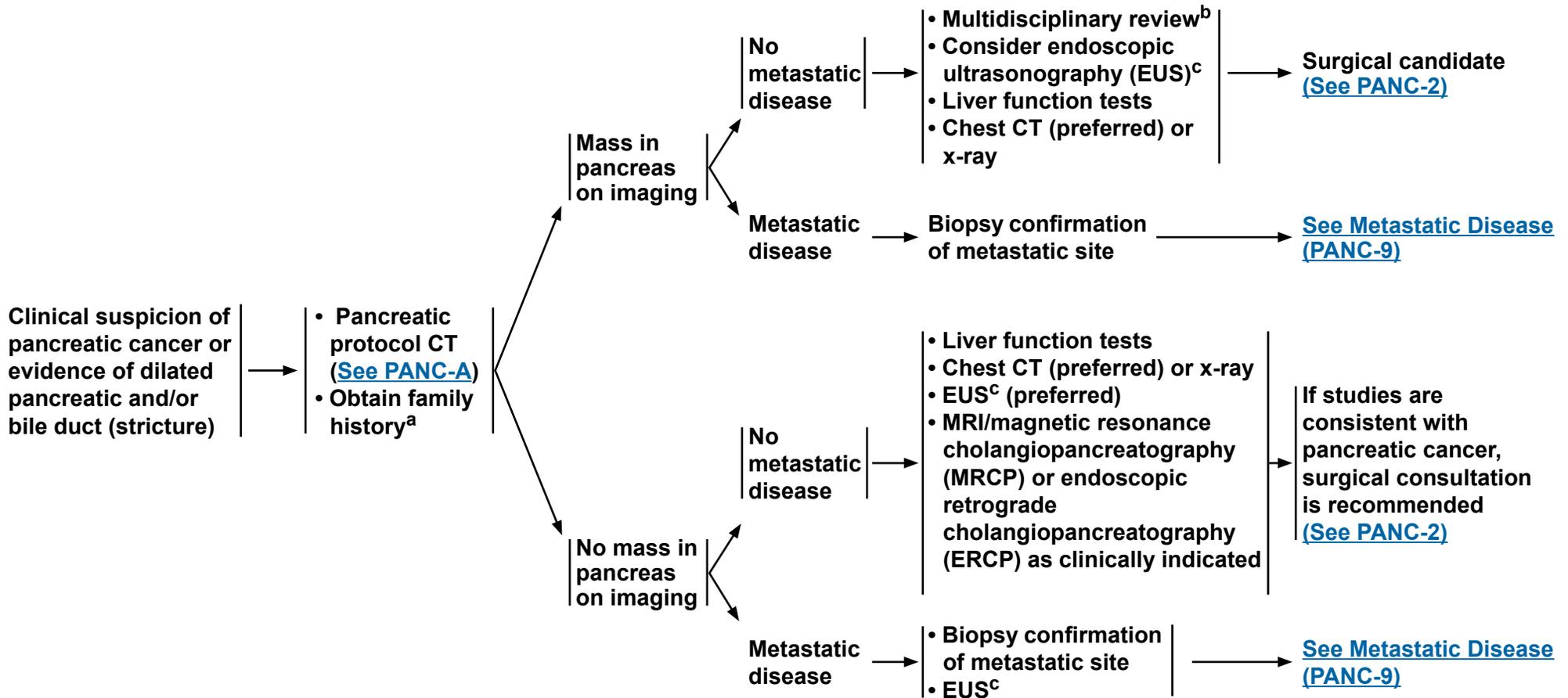


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Pancreatic Adenocarcinoma

CLINICAL PRESENTATION

WORKUP



^aIf pancreatic cancer is diagnosed, consider referral for genetic counseling for patients who are young or who have a family history of cancer.

^bMultidisciplinary review should ideally involve expertise from diagnostic imaging, interventional endoscopy, medical oncology, radiation oncology, surgery, and pathology.

^cEUS-FNA if clinically indicated.

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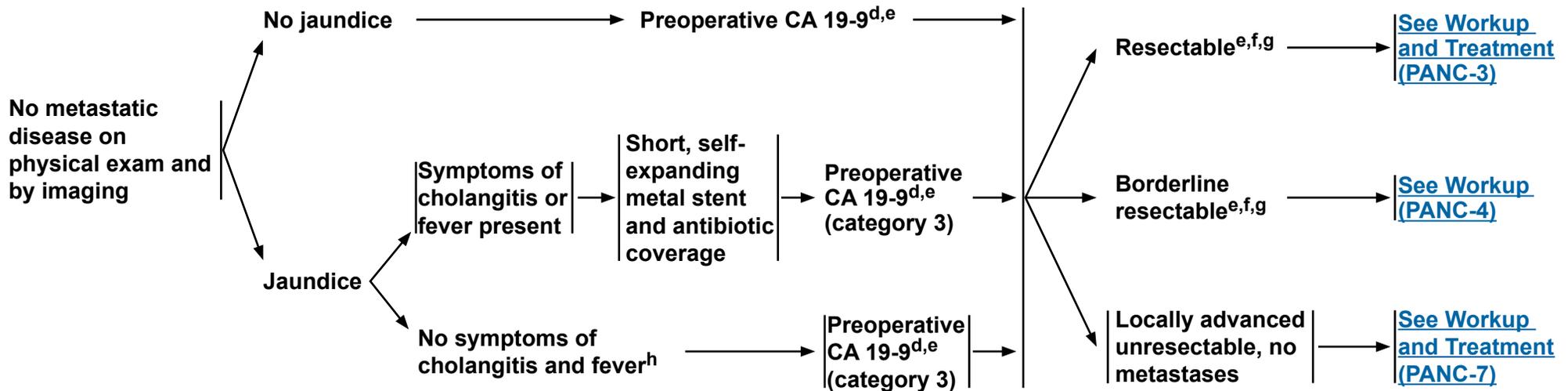


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Pancreatic Adenocarcinoma

CLINICAL PRESENTATION

WORKUP



^dElevated CA 19-9 does not necessarily indicate cancer or advanced disease. CA 19-9 may be elevated as a result of biliary infection (cholangitis), inflammation, or obstruction, benign or malignant. In addition, CA 19-9 may be undetectable in Lewis antigen-negative individuals. ([See Discussion](#))

^e[See Principles of Diagnosis, Imaging, and Staging \(PANC-A\)](#).

^f[See Criteria Defining Resectability Status \(PANC-B\)](#).

^g[See Principles of Surgical Technique \(PANC-C\)](#) and [Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting \(PANC-D\)](#).

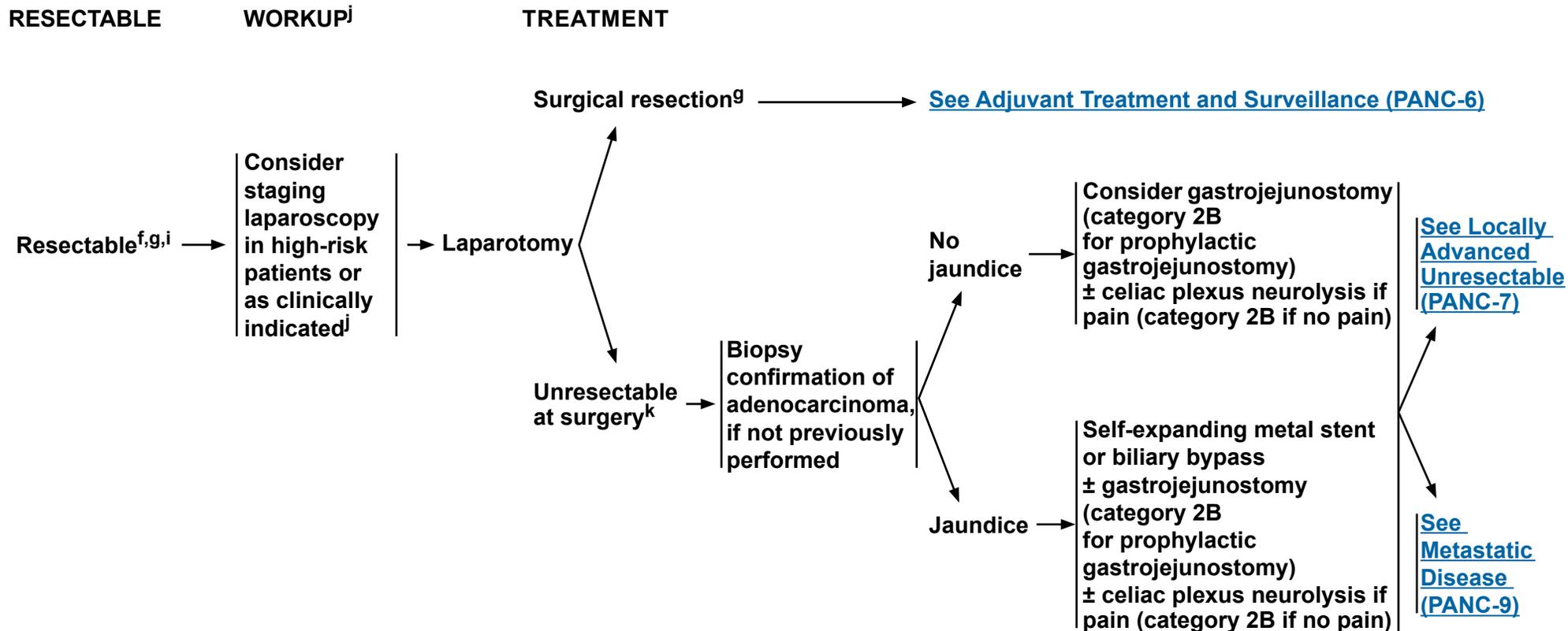
^hSelf-expanding metal stent as clinically indicated in patients with select comorbidities or when surgery may be delayed. ([See Discussion](#))

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^fSee [Criteria Defining Resectability Status \(PANC-B\)](#).

^gSee [Principles of Surgical Technique \(PANC-C\)](#) and [Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting \(PANC-D\)](#).

ⁱFor patients with tumors that are clearly resectable and who do not have high-risk features, neoadjuvant therapy is only recommended in a clinical trial. For patients with high-risk features (ie, very highly elevated CA 19-9, large primary tumors, large regional lymph nodes, excessive weight loss, extreme pain), neoadjuvant chemotherapy may be considered, which requires biopsy confirmation of adenocarcinoma (see [PANC-4](#)). Acceptable neoadjuvant regimens include FOLFIRINOX or gemcitabine + albumin-bound paclitaxel. Subsequent chemoradiation is sometimes included. Most NCCN Member Institutions prefer neoadjuvant therapy at a high-volume center.

^jSee [Principles of Diagnosis, Imaging, and Staging #8 \(PANC-A\)](#).

^kSee [Principles of Palliation and Supportive Care \(PANC-E\)](#).

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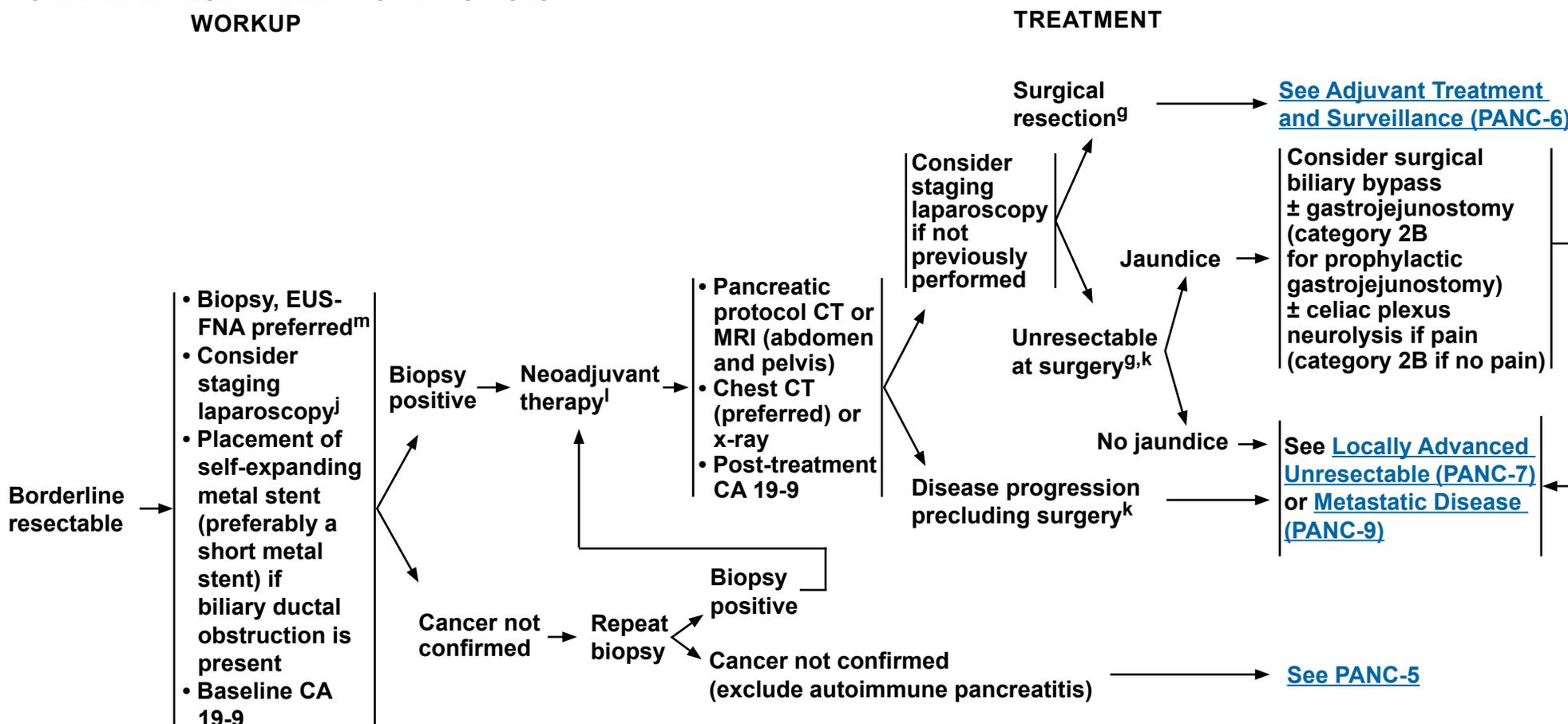
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BORDERLINE RESECTABLE^{e,f} NO METASTASES WORKUP



^eSee Principles of Diagnosis, Imaging, and Staging (PANC-A).

^fSee Criteria Defining Resectability Status (PANC-B).

^gSee Principles of Surgical Technique (PANC-C) and Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting (PANC-D).

^jSee Principles of Diagnosis, Imaging and Staging #8 (PANC-A).

^kSee Principles of Palliation and Supportive Care (PANC-E).

^lThere is limited evidence to recommend specific neoadjuvant regimens off-study, and practices vary with regard to the use of chemotherapy and chemoradiation. Acceptable regimens include FOLFIRINOX or gemcitabine + albumin-bound paclitaxel (see PANC-G). Subsequent chemoradiation is sometimes included (see PANC-F). Most NCCN Member Institutions prefer neoadjuvant therapy at a high-volume center. Performing surgery with a high likelihood of a positive margin is not recommended.

^mSee Principles of Diagnosis, Imaging and Staging #1 and #7 (PANC-A).

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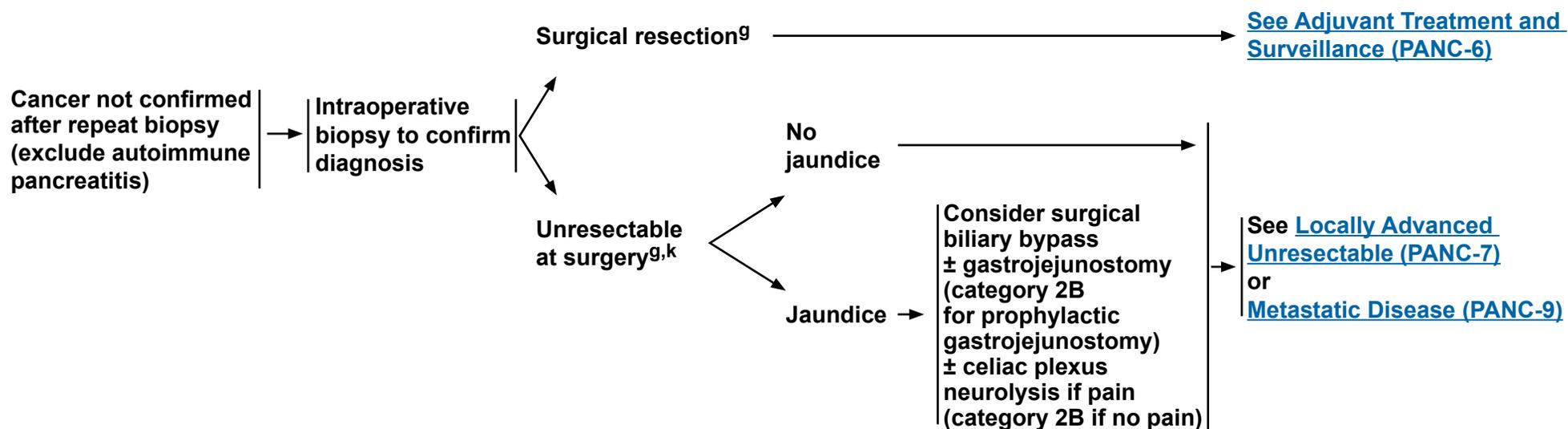
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BORDERLINE RESECTABLE^f NO METASTASES, CANCER NOT CONFIRMED TREATMENT



^fSee [Criteria Defining Resectability Status \(PANC-B\)](#).

^gSee [Principles of Surgical Technique \(PANC-C\)](#) and [Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting \(PANC-D\)](#).

^kSee [Principles of Palliation and Supportive Care \(PANC-E\)](#).

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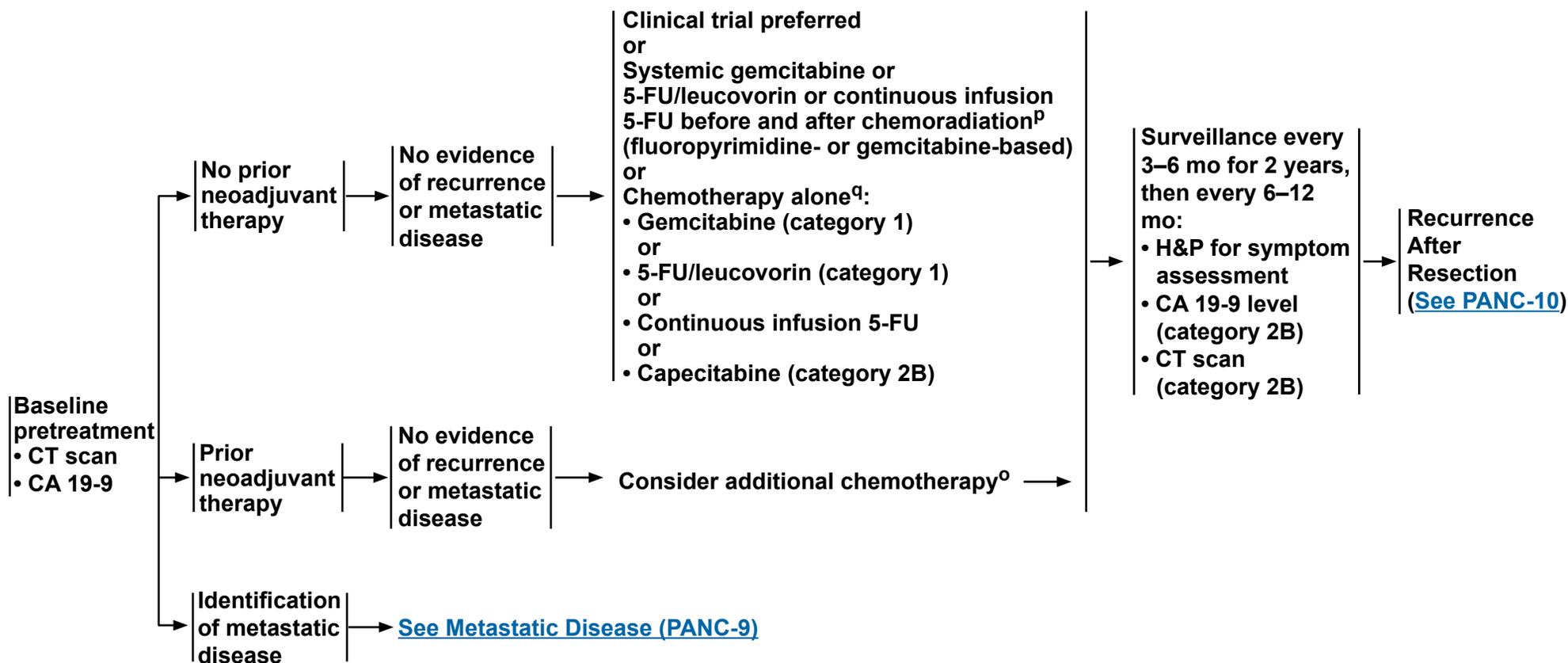


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Pancreatic Adenocarcinoma

POSTOPERATIVE ADJUVANT TREATMENT^{n,o}

SURVEILLANCE



ⁿAdjuvant treatment should be administered to patients who have not had neoadjuvant chemotherapy and who have adequately recovered from surgery; treatment should be initiated within 12 weeks. If systemic chemotherapy precedes chemoradiation, restaging with imaging should be done after each treatment modality.

^oPatients who have received neoadjuvant chemoradiation or chemotherapy may be candidates for additional chemotherapy following surgery and multidisciplinary review. The adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.

^pSee [Principles of Radiation Therapy \(PANC-F\)](#).

^qSee [Principles of Chemotherapy \(PANC-G\)](#).

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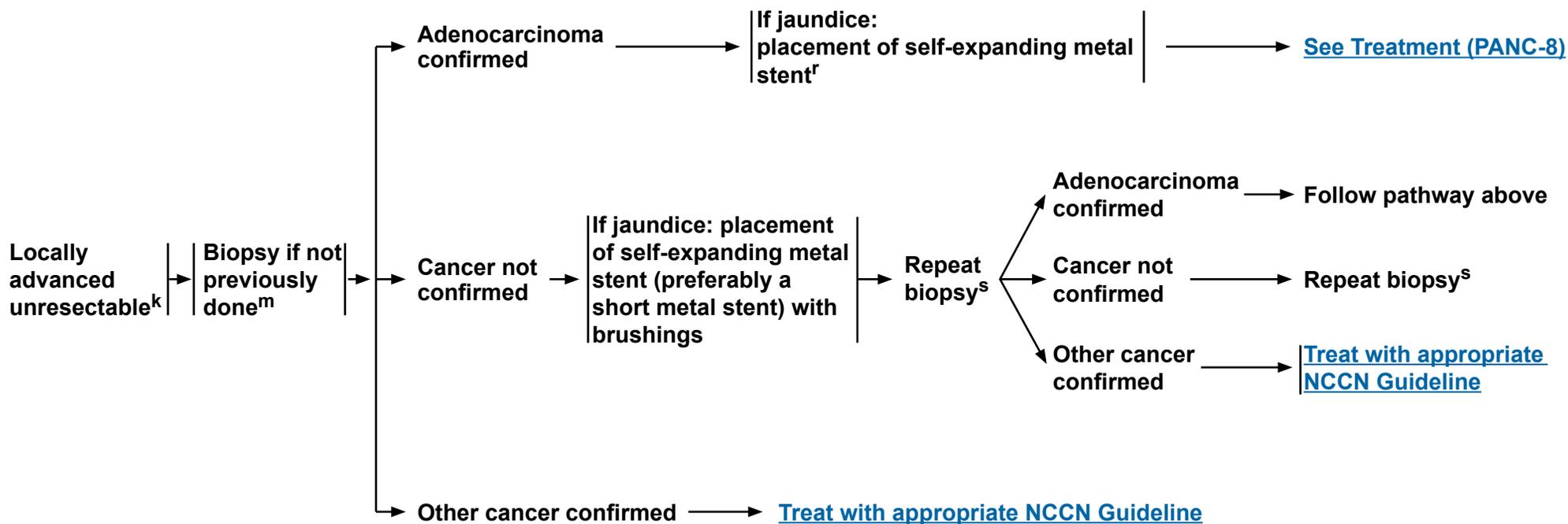


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Pancreatic Adenocarcinoma

LOCALLY ADVANCED UNRESECTABLE

WORKUP



^kSee Principles of Palliation and Supportive Care (PANC-E).

^mSee Principles of Diagnosis, Imaging and Staging #1 and #7 (PANC-A).

^rUnless biliary bypass performed at time of laparoscopy or laparotomy.

^sEUS-FNA ± core biopsy at a center with multidisciplinary expertise is preferred.

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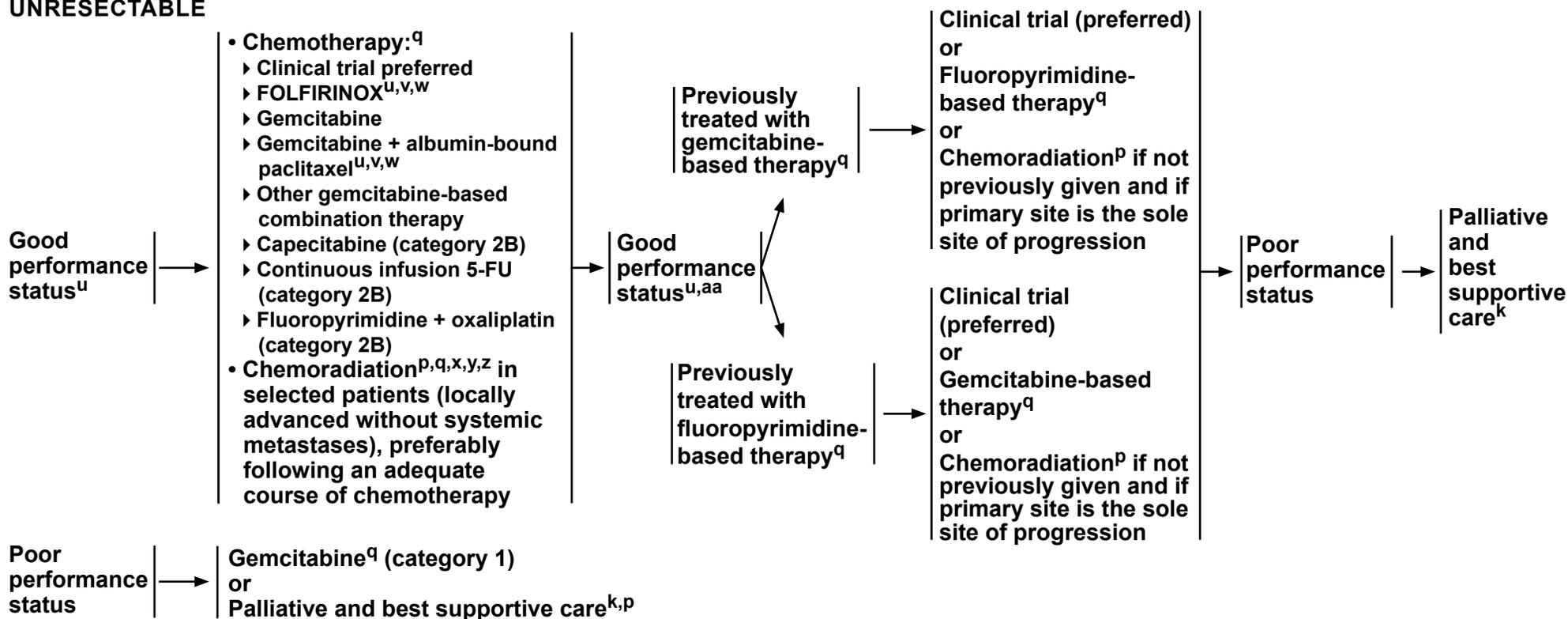
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Pancreatic Adenocarcinoma

LOCALLY ADVANCED UNRESECTABLE

FIRST-LINE THERAPY^t

SECOND-LINE THERAPY^{t,bb}



^kSee Principles of Palliation and Supportive Care (PANC-E).

^pSee Principles of Radiation Therapy (PANC-F).

^qSee Principles of Chemotherapy (PANC-G).

^tSee Principles of Diagnosis, Imaging and Staging #10 (PANC-A).

^uDefined as ECOG 0-1 with good pain management, patent biliary stent, and adequate nutritional intake.

^vFOLFIRINOX should be limited to those with ECOG 0-1. Gemcitabine + albumin-bound paclitaxel is reasonable for patients with KPS ≥70.

^wThe recommendations for FOLFIRINOX and gemcitabine + albumin-bound paclitaxel in patients with locally advanced disease are based on extrapolations from randomized trials in patients with metastatic disease.

^xChemoradiation should be reserved for patients who do not develop metastatic disease while receiving systemic chemotherapy.

^yBased on preliminary data from the LAP-07 trial, there is no clear survival benefit with the addition of conventional chemoradiation following gemcitabine monotherapy. Chemoradiation may improve local control and delay the need for resumption therapy. (Huguet F, Hammel P, Vernerey D, et al. Impact of chemoradiotherapy on local control and time without treatment in patients with locally advanced pancreatic cancer included in the international phase III LAP 07 study. J Clin Oncol 2014; 32:5s. Abstract 4001.)

^zLaparoscopy as indicated to evaluate distant disease.

^{aa}Patients with a significant response to therapy may be considered for surgical resection.

^{bb}Best reserved for patients who maintain a good performance status.

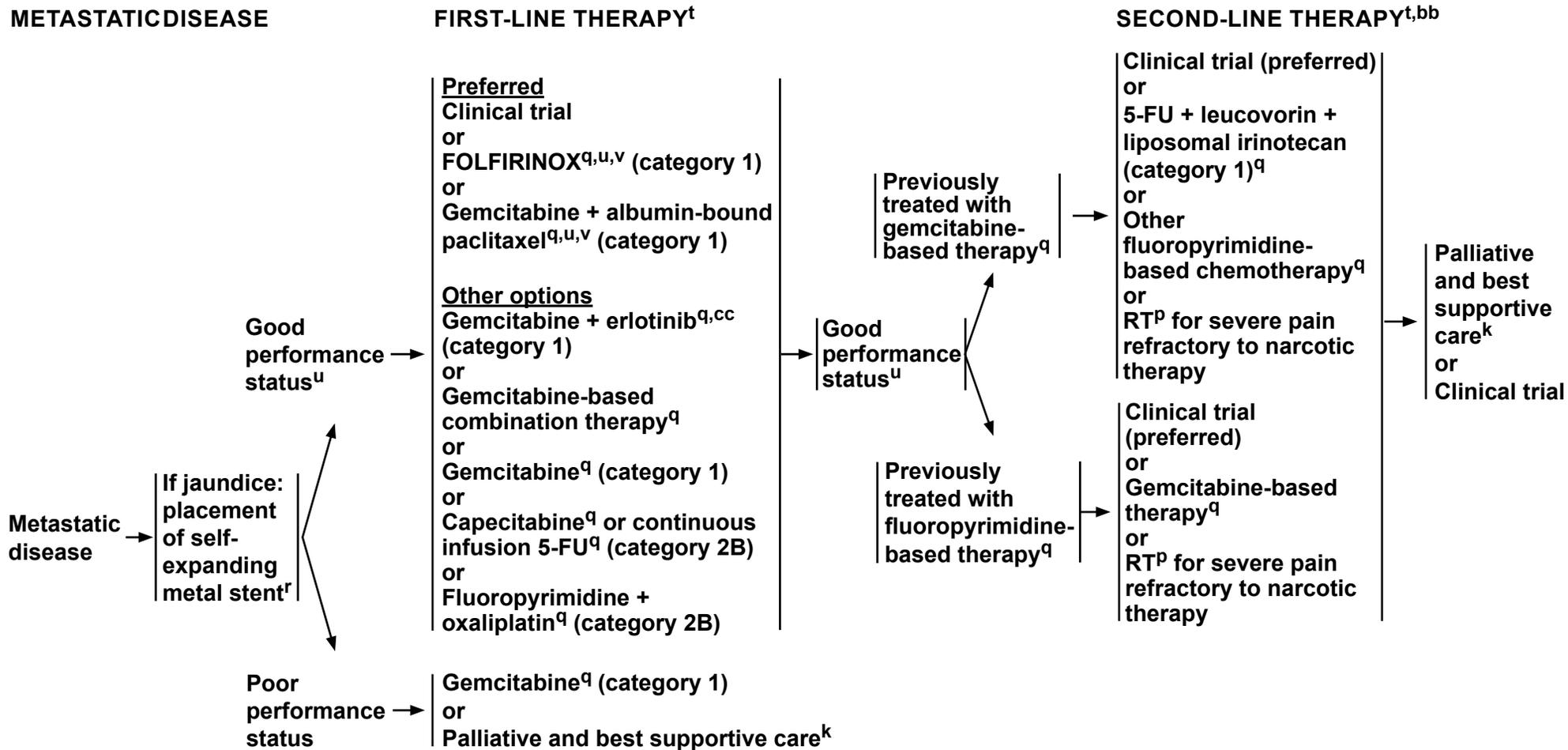
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Pancreatic Adenocarcinoma



^kSee Principles of Palliation and Supportive Care (PANC-E).

^pSee Principles of Radiation Therapy (PANC-F).

^qSee Principles of Chemotherapy (PANC-G).

^rUnless biliary bypass performed at time of laparoscopy or laparotomy.

^tSee Principles of Diagnosis, Imaging and Staging #10 (PANC-A).

^uDefined as ECOG 0-1 with good pain management, patent biliary stent, and adequate nutritional intake.

^vFOLFIRINOX should be limited to those with ECOG 0-1. Gemcitabine + albumin-bound paclitaxel is reasonable for patients with KPS ≥70.

^{bb}Best reserved for patients who maintain a good performance status.

^{cc}Although this combination significantly improved survival, the actual benefit was small, suggesting that only a small subset of patients benefit.

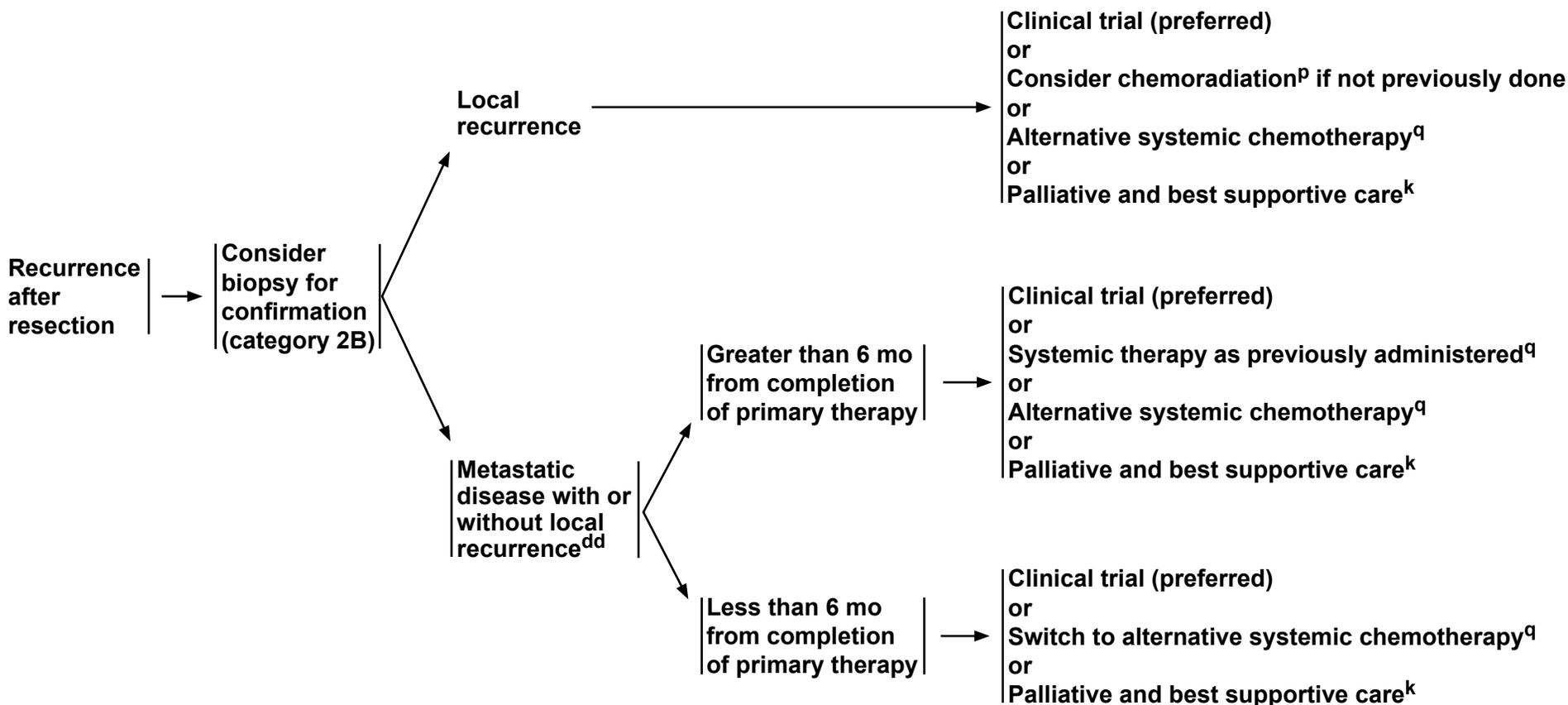
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RECURRENCE AFTER RESECTION

SECOND-LINE THERAPY^{bb}



^kSee Principles of Palliation and Supportive Care (PANC-E).

^PSee Principles of Radiation Therapy (PANC-F).

^qSee Principles of Chemotherapy (PANC-G).

^{bb}Best reserved for patients who maintain a good performance status.

^{dd}For more information about the treatment of isolated pulmonary metastases, see Discussion.

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**PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING**

- #1 Decisions about diagnostic management and resectability should involve multidisciplinary consultation at a high-volume center with reference to appropriate high-quality imaging studies to evaluate the extent of disease. Resections should be done at institutions that perform a large number (at least 15–20) of pancreatic resections annually.**
- #2 High-quality dedicated imaging of the pancreas should be performed at presentation (even if standard CT imaging is already available) and following neoadjuvant treatment to provide adequate staging and assessment of resectability status.**
- #3 Imaging should include dedicated pancreatic CT (preferred) or MRI.**
- **Multi-detector computed tomography (MDCT) angiography, performed by acquiring thin, preferably sub-millimeter, axial sections using a dual-phase pancreatic protocol, with images obtained in the pancreatic and portal venous phase of contrast enhancement, is the preferred imaging tool for dedicated pancreatic imaging.¹ Scan coverage can be extended to cover the chest and pelvis for complete staging as per institutional preferences. Multiplanar reconstruction is preferred as it allows precise visualization of the relationship of the primary tumor to the mesenteric vasculature as well as detection of subcentimeter metastatic deposits. [See MDCT Pancreas Adenocarcinoma Protocol, PANC-A \(3 of 8\)](#).**
 - **MRI is most commonly used as a problem-solving tool, particularly for characterization of CT-indeterminate liver lesions and when suspected pancreatic tumors are not visible on CT or when contrast-enhanced CT cannot be obtained (as in cases with severe allergy to iodinated intravenous contrast material). This preference for using MDCT as the main imaging tool in many hospitals and imaging centers is mainly due to the higher cost and lack of widespread availability of MRI compared to CT. [See MRI Pancreatic Adenocarcinoma Protocol, PANC-A \(4 of 8\)](#).**
 - **MR cholangiopancreatography (MRCP) without IV contrast should not be utilized in the staging of pancreatic cancer, except in cases of renal failure or other contraindications to administration of gadolinium intravenous contrast.**
- #4 The decision regarding resectability status should be made by consensus at multidisciplinary meetings/discussions following the acquisition of dedicated pancreatic imaging including complete staging. Use of a radiology staging reporting template is preferred to ensure complete assessment and reporting of all imaging criteria essential for optimal staging, which will improve the decision-making process.¹ [See Pancreatic Cancer Radiology Reporting Template, PANC-A \(5 of 8\)](#)**

[Continued on next page](#)

¹Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. *Radiology* 2014 Jan; 270(1):248-260.

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PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING

- #5 The role of PET/CT (without iodinated intravenous contrast) scan remains unclear. Diagnostic CT or MRI with IV contrast as discussed above in conjunction with functional PET imaging can be used per institutional preference. PET/CT scan may be considered after formal pancreatic CT protocol in high-risk² patients to detect extra pancreatic metastases. It is not a substitute for high-quality, contrast-enhanced CT.**
- #6 EUS is not recommended as a routine staging tool. In select cases, EUS may be complementary to CT for staging.**
- #7 EUS-FNA is preferable to a CT-guided FNA in patients with resectable disease because of better diagnostic yield, safety, and potentially lower risk of peritoneal seeding with EUS-FNA when compared with the percutaneous approach. Biopsy proof of malignancy is not required before surgical resection, and a non-diagnostic biopsy should not delay surgical resection when the clinical suspicion for pancreatic cancer is high.**
- #8 Diagnostic staging laparoscopy to rule out metastases not detected on imaging (especially for body and tail lesions) is used in some institutions prior to surgery or chemoradiation, or selectively in patients who are at higher risk² for disseminated disease. Intraoperative ultrasound can be used as a diagnostic adjunct during staging laparoscopy.**
- #9 Positive cytology from washings obtained at laparoscopy or laparotomy is equivalent to M1 disease. If resection has been done for such a patient, he or she should be treated for M1 disease.**
- #10 For locally advanced/metastatic disease, the panel recommends serial CT (routine single portal venous phase or dedicated pancreatic protocol if surgery is still contemplated) or MRI of known sites of disease to determine therapeutic benefit. It is recognized that patients can demonstrate progressive disease clinically without objective radiologic evidence of disease progression.**

[Continued on next page](#)

²Indicators of high-risk patients may include borderline resectable disease, markedly elevated CA 19-9, large primary tumors, or large regional lymph nodes.

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Pancreatic Adenocarcinoma

PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING

MDCT Pancreatic Adenocarcinoma Protocol¹

Parameters	Details
Scan type	Helical (preferably 64-multidetector row scanner or more)
Section thickness	Thinnest possible (<3 mm). Preferably submillimeter (0.5–1 mm) if available
Interval	Same as section thickness (no gap)
Oral contrast agent	Neutral contrast (positive oral contrast may compromise the three-dimensional [3D] and maximum intensity projection [MIP] reformatted images)
Intravenous contrast	Iodine-containing contrast agents (preferably high concentration [>300 mg I/L]) at an injection rate of 3–5 mL/sec. Lower concentration contrast can be used if low Kv setting is applied.
Scan acquisition timing	Pancreatic parenchymal phase at 40–50 sec and portal venous phase at 65–70 sec, following the commencement of contrast injection
Image reconstruction and display	<ul style="list-style-type: none"> - Axial images and multiplanar reformats (in the coronal, and per institutional preference, sagittal plane) at 2–3 mm interval reconstruction - MIP or 3D volumetric thick section for vascular evaluation (arteries and veins)

[Continued on next page](#)

¹Adapted from: Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. Radiology 2014 Jan; 270(1):248-260.

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Pancreatic Adenocarcinoma**PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING****MRI Pancreatic Adenocarcinoma Protocol**³

Sequences	Plane	Slice thickness
T2-weighted single-shot fast spin-echo (SSFSE)	Coronal +/- axial	<6 mm
T1-weighted in-phase and opposed-phase gradient echo (GRE)	Axial	<6 mm
T2-weighted fat-suppressed fast spin-echo (FSE)	Axial	<6 mm
Diffusion-weighted imaging (DWI)	Axial	<6 mm
Pre and dynamic post IV contrast administration (gadolinium⁴) Three-dimensional [3D] T1-weighted fat-suppressed gradient-echo (in pancreatic, portal venous, and equilibrium phases)	Axial	Thinnest possible 2–3 mm (4–6 mm if overlapping)
T2-weighted MRCP (preferably three-dimensional [3D], fast relaxation fast spin-echo sequence [FRFSE])	Coronal	<3 mm

[Continued on next page](#)

³Sheridan MB, Ward J, Guthrie JA, et al. Dynamic contrast-enhanced MR imaging and dual-phase helical CT in the preoperative assessment of suspected pancreatic cancer: a comparative study with receiver operating characteristic analysis. AJR Am J Roentgenol 1999 Sep;173 (3):583-90.

⁴Unenhanced MRI can be obtained in cases of renal failure or contraindication to gadolinium intravenous contrast if enhanced CT cannot be obtained due to severe iodinated contrast allergy.

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Pancreatic Adenocarcinoma

PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING PANCREATIC CANCER RADIOLOGY REPORTING TEMPLATE¹

Morphologic Evaluation			
Appearance (in the pancreatic parenchymal phase)	<input type="checkbox"/> Hypoattenuating	<input type="checkbox"/> Isoattenuating	<input type="checkbox"/> Hyperattenuating
Size (maximal axial dimension in centimeters)	<input type="checkbox"/> Measurable	<input type="checkbox"/> Nonmeasurable (isoattenuating tumors)	
Location	<input type="checkbox"/> Head/uncinate (right of SMV)	<input type="checkbox"/> Body/tail (left of SMV)	
Pancreatic duct narrowing/abrupt cutoff with or without upstream dilatation	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	
Biliary tree abrupt cutoff with or without upstream dilatation	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	

[Reporting Template continued on next page](#)

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Pancreatic Adenocarcinoma

PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING PANCREATIC CANCER RADIOLOGY REPORTING TEMPLATE¹

Arterial Evaluation				
SMA Contact	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Focal vessel narrowing or contour irregularity	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Extension to first SMA branch	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Celiac Axis Contact				
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Focal vessel narrowing or contour irregularity	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
CHA Contact				
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Focal vessel narrowing or contour irregularity	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Extension to celiac axis	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Extension to bifurcation of right/left hepatic artery	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Arterial Variant				
Variant anatomy	<input type="checkbox"/> Accessory right hepatic artery	<input type="checkbox"/> Replaced right hepatic artery	<input type="checkbox"/> Replaced common hepatic artery	<input type="checkbox"/> Others (origin of replaced or accessory artery) _____
Variant vessel contact	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180		
Focal vessel narrowing or contour irregularity	<input type="checkbox"/> Present	<input type="checkbox"/> Absent		

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[Reporting Template continued on next page](#)

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Pancreatic Adenocarcinoma

PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING

PANCREATIC CANCER RADIOLOGY REPORTING TEMPLATE¹

Venous Evaluation			
MPV Contact	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	<input type="checkbox"/> Complete occlusion
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180	
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180	
Focal vessel narrowing or contour irregularity (tethering or tear drop)	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	
SMV Contact			
SMV Contact	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	<input type="checkbox"/> Complete occlusion
Degree of solid soft-tissue contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180	
Degree of increased hazy attenuation/stranding contact	<input type="checkbox"/> ≤180	<input type="checkbox"/> >180	
Focal vessel narrowing or contour irregularity (tethering or tear drop)	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	
Extension	<input type="checkbox"/> Present	<input type="checkbox"/> Absent	
Other			
Thrombus within vein (tumor, bland)	<input type="checkbox"/> Present <input type="checkbox"/> MPV <input type="checkbox"/> SMV <input type="checkbox"/> Splenic vein	<input type="checkbox"/> Absent	
Venous collaterals	<input type="checkbox"/> Present <input type="checkbox"/> Around pancreatic head <input type="checkbox"/> Porta hepatis <input type="checkbox"/> Root of the mesentery <input type="checkbox"/> Left upper quadrant	<input type="checkbox"/> Absent	

[Reporting Template continued on next page](#)

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NCCN Guidelines Version 2.2016

Pancreatic Adenocarcinoma

PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING PANCREATIC CANCER RADIOLOGY REPORTING TEMPLATE¹

Extrapancreatic Evaluation		
Liver lesions	<input type="checkbox"/> Present <input type="checkbox"/> Suspicious <input type="checkbox"/> Indeterminate <input type="checkbox"/> Likely benign	<input type="checkbox"/> Absent
Peritoneal or omental nodules	<input type="checkbox"/> Present	<input type="checkbox"/> Absent
Ascites	<input type="checkbox"/> Present	<input type="checkbox"/> Absent
Suspicious lymph nodes	<input type="checkbox"/> Present <input type="checkbox"/> Porta hepatis <input type="checkbox"/> Celiac <input type="checkbox"/> Splenic hilum <input type="checkbox"/> Paraaortic <input type="checkbox"/> Aortocaval <input type="checkbox"/> Other _____	<input type="checkbox"/> Absent
Other extrapancreatic disease (invasion of adjacent structures)	<input type="checkbox"/> Present • Organs involved: _____	<input type="checkbox"/> Absent
Impression		
	Tumor size: _____	Tumor location: _____
Vascular contact	<input type="checkbox"/> Present • Vessel involved: _____ • Extent: _____	<input type="checkbox"/> Absent
Metastasis	<input type="checkbox"/> Present (Location _____)	<input type="checkbox"/> Absent

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NCCN Guidelines Version 2.2016

Pancreatic Adenocarcinoma

CRITERIA DEFINING RESECTABILITY STATUS¹

Resectability Status	Arterial	Venous
Resectable	No arterial tumor contact (celiac axis [CA], superior mesenteric artery [SMA], or common hepatic artery [CHA]).	No tumor contact with the superior mesenteric vein (SMV) or portal vein (PV) or $\leq 180^\circ$ contact without vein contour irregularity.
Borderline Resectable ²	<p><u>Pancreatic head /uncinate process:</u></p> <ul style="list-style-type: none"> • Solid tumor contact with CHA without extension to celiac axis or hepatic artery bifurcation allowing for safe and complete resection and reconstruction. • Solid tumor contact with the SMA of $\leq 180^\circ$ • Presence of variant arterial anatomy (ex: accessory right hepatic artery, replaced right hepatic artery, replaced CHA and the origin of replaced or accessory artery) and the presence and degree of tumor contact should be noted if present as it may affect surgical planning. <p><u>Pancreatic body/tail:</u></p> <ul style="list-style-type: none"> • Solid tumor contact with the CA of $\leq 180^\circ$ • Solid tumor contact with the CA of $>180^\circ$ without involvement of the aorta and with intact and uninvolved gastroduodenal artery [some members prefer this criteria to be in the unresectable category]. 	<ul style="list-style-type: none"> • Solid tumor contact with the SMV or PV of $>180^\circ$, contact of $\leq 180^\circ$ with contour irregularity of the vein or thrombosis of the vein but with suitable vessel proximal and distal to the site of involvement allowing for safe and complete resection and vein reconstruction. • Solid tumor contact with the inferior vena cava (IVC).
Unresectable ²	<ul style="list-style-type: none"> • Distant metastasis (including non-regional lymph node metastasis) <p><u>Head/uncinate process:</u></p> <ul style="list-style-type: none"> • Solid tumor contact with SMA $>180^\circ$ • Solid tumor contact with the CA $>180^\circ$ • Solid tumor contact with the first jejunal SMA branch <p><u>Body and tail</u></p> <ul style="list-style-type: none"> • Solid tumor contact of $>180^\circ$ with the SMA or CA • Solid tumor contact with the CA and aortic involvement 	<p><u>Head/uncinate process</u></p> <ul style="list-style-type: none"> • Unreconstructible SMV/PV due to tumor involvement or occlusion (can be due to tumor or bland thrombus) • Contact with most proximal draining jejunal branch into SMV <p><u>Body and tail</u></p> <ul style="list-style-type: none"> • Unreconstructible SMV/PV due to tumor involvement or occlusion (can be due to tumor or bland thrombus)

¹Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the Society of Abdominal Radiology and the American Pancreatic Association. Radiology 2014 Jan; 270(1):248-260.

²Solid tumor contact may be replaced with increased hazy density/stranding of the fat surrounding the peri-pancreatic vessels (typically seen following neoadjuvant therapy); this finding should be reported on the staging and follow-up scans. Decision on resectability status should be made in these patients, in consensus at multidisciplinary meetings/discussions.

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**PRINCIPLES OF SURGICAL TECHNIQUE****Pancreatoduodenectomy (Whipple technique)**

The goals of surgical extirpation of pancreatic carcinoma focus on the achievement of an R0 resection, as a margin-positive specimen is associated with poor long-term survival.^{1,2} Achievement of a margin-negative dissection must focus on meticulous perivascular dissection of the lesion in resectional procedures, recognition of the need for vascular resection and/or reconstruction, and the potential need for extra-pancreatic organ resection. Of course the biology of the cancer might not allow for an R0 resection even with the most meticulous surgery.

- Medial dissection of pancreatic head lesions is best achieved by complete mobilization of the portal and SMV from the uncinate process (assuming no evidence of tumor infiltration). Skeletalization of the lateral, posterior, and anterior borders of the superior mesenteric artery down to the level of the adventitia will maximize uncinate yield and radial margin.^{3,4}
- In the absence of frank venous occlusion noted on preoperative imaging, the need for lateral venorrhaphy or complete portal or SMV resection and reconstruction to achieve an R0 resection may be suggested but is often not known until division of the pancreatic neck has occurred. Tethering of the carcinoma to the lateral wall of the PV is not uncommon and requires careful dissection to free the vein from the pancreatic head if in fact it is possible to do so. Differentiation of tumor infiltration into the vein wall from tumor-related desmoplasia is frequently impossible to ascertain. Data support an aggressive approach to partial or complete vein excision if tumor infiltration is suspected, although acceptance of this concept (particularly with respect to vein resection) is not universal.
- While further data with respect to arterial resection are clearly needed, judicious utilization of this technique would appear to be reasonable in very select populations.

Distal Pancreatectomy

The goals of left-sided resection are similar to those of pancreatoduodenectomy, although they are often more difficult to achieve due to the advanced stage at which most of these cancers are discovered.

- An R0 distal pancreatectomy for adenocarcinoma mandates en bloc organ removal beyond that of the spleen alone in up to 40% of patients.^{5,6}
- Similar to the Whipple procedure, lateral venorrhaphy, vein excision and reconstruction, and dissection to the level of the celiac axis and SMA adventitia should be performed if complete tumor clearance can be achieved.^{5,7}
- Spleen preservation is not indicated in adenocarcinoma.

¹Bilimoria KY, Talamonti MS, Sener SF, et al. Effect of hospital volume on margin status after pancreaticoduodenectomy for cancer. *J Am Coll Surg.* Oct 2008;207(4):510-519.

²Winter JM, Cameron JL, Campbell KA, et al. 1423 pancreaticoduodenectomies for pancreatic cancer: A single-institution experience. *J Gastrointest Surg.* Nov 2006;10(9):1199-1210; discussion 1210-1191.

³Yeo TP, Hruban RH, Leach SD, et al. Pancreatic cancer. *Curr. Probl. Cancer.* Jul-Aug 2002;26(4):176-275.

⁴Nakeeb A, Lillemoe KD, Grosfeld JL. Surgical techniques for pancreatic cancer. *Minerva Chir.* Apr 2004;59(2):151-163.

⁵Shoup M, Conlon KC, Klimstra D, et al. Is extended resection for adenocarcinoma of the body or tail of the pancreas justified? *J Gastro Surg.* Dec 2003;7(8):946-952; discussion 952.

⁶Christein JD, Kendrick ML, Iqbal CW, et al. Distal pancreatectomy for resectable adenocarcinoma of the body and tail of the pancreas. *J Gastrointest Surg.* Sep-Oct 2005;9(7):922-927.

⁷Strasberg SM, Linehan DC, Hawkins WG. Radical antegrade modular pancreatosplenectomy procedure for adenocarcinoma of the body and tail of the pancreas: ability to obtain negative tangential margins. *J Am Coll Surg.* Feb 2007;204(2):244-249.

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**PATHOLOGIC ANALYSIS: SPECIMEN ORIENTATION, HISTOLOGIC SECTIONS, AND REPORTING**

The primary purpose of pathologic analysis of the pancreatic specimen is to determine the pathologic stage of the tumor by evaluating the type, grade, size, and extent of the cancer.

Whipple Specimen**• Specimen orientation**

- ▶ Specimen orientation and inking involves both the pathologist and surgeon as this will help to ensure accurate assessment of the size and extent of the tumor. There should be either direct communication between the surgeon and pathologist for proper orientation and margin identification, or the surgeon should identify the important margins with a clearly understood and documented method (eg, written on the pathology requisition); for example: stitch on posterior margin, safety pin on the retroperitoneal/uncinate margin.

• Margins

- ▶ Definitions of the margins and uniformity of nomenclature are critical to accurate reporting.

- ◊ **SMA (retroperitoneal/uncinate) Margin:** The most important margin is the soft tissue directly adjacent to the proximal 3–4 cm of the superior mesenteric artery. This margin is often referred to as the “retroperitoneal margin” or “posterior margin,” but has also been referred to as the “uncinate margin” or “mesenteric margin.” More recently, this margin has been referred to as the “SMA margin” to correlate with its location on the specimen. Radial rather than en face sections of this margin will more clearly demonstrate how closely this margin is approached by tumor. The simple step of palpating the specimen can help guide the pathologist as to the best spot along the SMA margin to select for sampling.
- ◊ **Posterior Margin:** This margin is from the posterior caudad aspect of the pancreatic head that merges with the uncinate margin and that appears to be covered by loose connective tissue. Radial rather than en face sections of this margin will more clearly demonstrate whether it is involved by tumor. In some instances this margin can be included in the same section as the SMA margin section.
- ◊ **Portal Vein Groove Margin:** This is the smooth-surfaced groove on the posterior-medial surface of the pancreatic head that rests over the PV. Radial rather than en face sections of this margin will more clearly demonstrate whether it is involved by tumor and also will provide the distance of the tumor from the margin. As is true for the posterior margin, in some instances this margin can be included in the same section as the SMA margin section.
- ◊ **Portal Vein Margins:** If an en bloc partial or complete vein resection is added to the surgical specimen it should be marked separately. En face proximal and distal end margins of the vein should be separately submitted as Proximal Portal Vein Margin and Distal Portal Vein Margin. A section documenting tumor invasion into the vein wall should also be submitted. If feasible, this section should be a full thickness of the vein wall demonstrating the depth of tumor invasion, as this has been shown to have prognostic value.¹
- ◊ **Pancreatic Neck (transection) Margin:** This is the en face section of the transected pancreatic neck. The section should be placed into the cassette with the true margin facing up so that the initial section into the block represents the true surgical margin.
- ◊ **Bile Duct Margin:** This is the en face section of the bile duct end. The section should be removed from the unopened duct and placed into the cassette with the true margin facing up so that the initial section into the block represents the true surgical margin.
- ▶ Other margins analyzed in Whipple specimens include the proximal and distal enteric margins (en face sections) and anterior surface (closest representative). The anterior surface is not a true margin, but identification and reporting of this surface when positive may portend a risk of local recurrence, and therefore should be reported in all cases.²⁻⁵
- ▶ Collectively, these pancreatic tissue surfaces constitute the circumferential transection margin. Designating the various specific margins with different colored inks will allow recognition on microscopy.

[Continued on next page](#)

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**PATHOLOGIC ANALYSIS: SPECIMEN ORIENTATION, HISTOLOGIC SECTIONS, AND REPORTING****• Histologic sectioning**

- ▶ The approach to histologic sectioning is determined by the unique characteristics of the tumor, but is also influenced by institutional preferences, expertise, and experience. Options include axial, bi- or multi-valve slicing, and perpendicular sliding. Some experts in the field bisect the pancreas along probes placed in the bile and pancreatic ducts and then serially section along each half of the pancreas.
- ▶ Axial slicing provides an overall assessment of the epicenter of the tumor relative to the ampulla, bile duct, duodenum, and pancreas, and all of the pancreatic circumferential tissue margins mentioned above.
- ▶ There is no one correct way to dissect a Whipple specimen. The most important aspects of dissection are clear and accurate assessment of the margins.
- ▶ It is currently unknown what constitutes an adequate margin in pancreatic carcinoma resection specimens. A standardized definition of this would allow better stratification of patients into adjuvant regimens following surgical extirpation. For instance, if less than 1-mm clearance is associated with an unacceptably high incidence of local recurrence, then strong consideration for postoperative radiation therapy (RT) might be indicated if not received preoperatively. Tumor clearance should be reported in millimeters for all margins described above to allow prospective accumulation of these important data for future analysis.
- ▶ Attached organs resected with the specimen en bloc require serial sectioning to assess not only direct extension, but metastatic deposits as well. One section that demonstrates direct invasion of the organ and/or a separate metastatic deposit is required.
- ▶ Consider frozen section analysis of the pancreatic neck and bile duct. To avoid cautery artifact that may confound the frozen section, assess the pancreatic neck and bile duct at time of surgery by frozen section approximately 5 mm from the transection margin. If tumor is located within 5 mm of margins, consider further excision of the pancreas and bile duct to ensure at least 5 mm of clearance.

Distal Pancreatectomy

- In left-sided resections the peripancreatic soft tissue margins and the pancreatic neck are assessed. Additionally, involvement of the splenic vessels should be documented and invasion of the spleen is important to determine, as direct tumor invasion constitutes a pT3 pathologic stage.
- Margin definitions are as follows:
 - ▶ Proximal Pancreatic (transection) Margin: A full en face section of the pancreatic body along the plane of transection. The section should be placed into the cassette with the true margin facing up so that the initial section into the block represents the true surgical margin. More than one block may be needed.
 - ▶ Anterior (cephalad) Peripancreatic (peripheral) Surface: This surface demonstrates the relationship between the tumor and the anterior or cephalad peripancreatic soft tissue and can be representative if grossly positive. Several such sections should be taken closest to the tumor to document absence of involvement; the exact number is dependent on the degree of ambiguity of gross involvement.
 - ▶ Posterior (caudad) Peripancreatic (peripheral) Margin: This margin demonstrates the relationship between the tumor and the posterior or caudad peripancreatic soft tissue and can be representative if grossly positive. Several such sections should be taken closest to the tumor to document absence of involvement; the exact number is dependent on the degree of ambiguity of gross involvement.

[Continued on next page](#)**Note:** All recommendations are category 2A unless otherwise indicated.**Clinical Trials:** NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

**PATHOLOGIC ANALYSIS: SPECIMEN ORIENTATION, HISTOLOGIC SECTIONS, AND REPORTING****Reporting**

The NCCN Pancreatic Cancer Panel currently supports pathology synoptic reports from the College of American Pathologists (CAP). The proposal included herein is an abbreviated minimum analysis of pancreatic cancer specimens from the CAP recommendations. In addition to the standard TNM staging, other variables are included, all of which have prognostic implications in the evolution of this disease.^{6,7}

Specimen type

- Tumor size (obtained from careful gross measurement of the largest dimension of the tumor in cm.)
 - Histologic grade (G (x-4))
 - Primary tumor extent of invasion (T (x-4))
 - Regional lymph nodes (N (x-1))^a
 - ▶ # Nodes recovered
 - ▶ # Nodes involved
 - Metastases (M (0-1))
 - Margins: (Involvement should be defined and surgical clearance measured in mm)
 - ▶ Whipple resection:
 - ◇ SMA (retroperitoneal/uncinate) Margin
 - ◇ Posterior Margin
 - ◇ Portal Vein Groove Margin
 - ◇ Pancreatic Neck (transection) Margin
 - ◇ Bile Duct Margin
 - ◇ Enteric Margins
 - ◇ Anterior Surface
 - ▶ Distal pancreatectomy:
 - ◇ Proximal Pancreatic (transection) Margin
 - ◇ Anterior (cephalad) Peripancreatic (peripheral) Surface (optional)
 - ◇ Posterior (caudad) Peripancreatic (peripheral) Margin
 - Lymphatic (small vessel) Invasion (L)
 - Vascular (large vessel) Invasion (V)
 - Perineural Invasion (P)
 - Additional pathologic findings
 - ▶ Pancreatic Intraepithelial Neoplasia
 - ▶ Chronic Pancreatitis
- Final stage: G, T, N, M, L, V, P

^aEvery effort should be made to identify all regional lymph nodes within the pancreatectomy specimen ([see Discussion](#)).

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PATHOLOGIC ANALYSIS: SPECIMEN ORIENTATION, HISTOLOGIC SECTIONS, AND REPORTING

References

- ¹Fukuda S, Oussoultzoglou E, Bachellier P, et al. Significance of the depth of portal vein wall invasion after curative resection for pancreatic adenocarcinoma. Arch surg Feb 2007;142(2):172-179; discussion 180.
- ²Verbeke CS. Resection margins and R1 rates in pancreatic cancer--are we there yet? Histopathol Jun 2008;52(7):787-796.
- ³The Royal College of Pathologists. Standards and minimum datasets for reporting cancers. Minimum dataset for the histopathological reporting of pancreatic, ampulla of Vater and bile duct carcinoma. The Royal College of Pathologists. 2002.
- ⁴Classification of pancreatic cancer. Japan Pancreas Society. 2nd ed. Tokyo: Kanehara; 2003.
- ⁵Hruban RH, Pitman MB, Klimstra DS. Tumors of the Pancreas. Atlas of Tumor Pathology, 4th series, fascicle 6. Washington, D.C.: American Registry of Pathology; Armed Forces Institutes of Pathology; 2007.
- ⁶Mitsunaga S, Hasebe T, Iwasaki M, et al. Important prognostic histological parameters for patients with invasive ductal carcinoma of the pancreas. Cancer Sci Dec 2005;96(12):858-865.
- ⁷Gebhardt C, Meyer W, Reichel M, Wunsch PH. Prognostic factors in the operative treatment of ductal pancreatic carcinoma. Langenbecks Arch Surg Jan 2000;385(1):14-20.

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PRINCIPLES OF PALLIATION AND SUPPORTIVE CARE^a

Objectives: Prevent and ameliorate suffering while ensuring optimal quality of life

- **Biliary obstruction**
 - ▶ Endoscopic biliary metal stent (preferred method)
 - ▶ Percutaneous biliary drainage with subsequent internalization
 - ▶ Open biliary-enteric bypass

- **Gastric outlet obstruction**
 - ▶ **Good performance status**
 - ◇ Gastrojejunostomy (open or laparoscopic) ± J-tube
 - ◇ Consider enteral stent^b
 - ▶ **Poor performance status**
 - ◇ Enteral stent^b
 - ◇ Venting percutaneous endoscopic gastrostomy (PEG) tube for gastric decompression

- **Severe tumor-associated abdominal pain that is unresponsive to optimal, around-the-clock narcotic administration, or if patient experiences undesirable narcotic associated side effects ([See NCCN Guidelines for Adult Cancer Pain](#))**
 - ▶ EUS-guided celiac plexus neurolysis (fluoroscopic- or CT-guided if unavailable)
 - ▶ Consider palliative radiation with or without chemotherapy if not already given as part of primary therapy regimen. [See Principles of Radiation Therapy \(PANC-F\)](#).

- **Depression, pain, and malnutrition ([See NCCN Guidelines for Supportive Care](#))**
 - ▶ Formal Palliative Medicine Service evaluation when appropriate
 - ▶ Nutritional evaluation when appropriate.

- **Pancreatic exocrine insufficiency**
 - ▶ Pancreatic enzyme replacement

- **Thromboembolic disease**
 - ▶ Low-molecular-weight heparin preferred over warfarin^c

^aPalliative surgical procedures are best reserved for patients with a longer life expectancy.

^bPlacement of an enteral stent is particularly important for patients with poor performance status and should be done after biliary drainage is assured.

^cA randomized trial examining the effects of prophylactic low-molecular-weight heparin showed a decrease in VTE but no effect on survival. (Pelzer U, Opitz B, Deuschinoff G, et al. Efficacy of prophylactic low-molecular weight heparin for ambulatory patients with advanced pancreatic cancer: Outcomes from the CONKO-004 trial. J Clin Oncol 2015;33:2028–2034.)

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PRINCIPLES OF RADIATION THERAPY

General Principles:

- Patients with pancreatic cancer are best managed by a multidisciplinary team.¹
- Recommendations for RT for such patients are typically made based upon five clinical scenarios:
1) neoadjuvant/resectable; 2) borderline resectable; 3) locally advanced/unresectable; 4) adjuvant/resectable; and 5) palliative. For definitions of these scenarios, [See Criteria Defining Resectability Status \(PANC-B\)](#).
- Staging is optimally determined with modern contrast-enhanced abdominal CT (3-D CT) and/or MRI imaging with thin cuts through the pancreas along with an EUS.
- If patients present with biliary obstruction (jaundice/elevated direct bilirubin), plastic or metal stents should be placed prior to initiation of RT. A percutaneous drain can also be used if ERCP stent placement is unsuccessful.
- The role of laparoscopic evaluation prior to chemoradiation is controversial, although standard at some institutions.
- Ideally, patients should be treated on clinical trials when available. Radiation is typically given concurrently with chemotherapy, except in the palliative setting.

Standard Recommendations:

****Note:** It is not known whether one regimen is necessarily more effective than another; hence, these are given as examples of commonly utilized regimens. However, other regimens based on similar principles are acceptable.

Neoadjuvant Resectable/Borderline Resectable:

- No standard treatment regimen currently exists for neoadjuvant resectable or borderline resectable pancreatic cancer. Neoadjuvant therapy for patients with resectable tumors should ideally be conducted in a clinical trial. Generally, use similar paradigms as for locally advanced unresectable disease.
 - ▶ Upfront fluoropyrimidine (CI-5-FU or capecitabine-based) chemoradiation.^{2,3}
 - ▶ Upfront gemcitabine-based chemoradiation.⁴
 - ▶ Induction chemotherapy (2–6 cycles) followed by 5-FU- or gemcitabine-based chemoradiation.⁵
- Ideally, surgical resection should be attempted 4–8 weeks following chemoradiation. Surgery can be performed >8 weeks following chemoradiation; however, radiation-induced fibrosis may potentially make surgery more difficult.

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**PRINCIPLES OF RADIATION THERAPY****Unresectable/Locally Advanced (non-metastatic):**

- ▶ Induction chemotherapy followed by 5-FU or gemcitabine-based chemoradiation.^{a,7,8}
- ▶ Upfront fluoropyrimidine (CI 5-FU or capecitabine)-based chemoradiation in select patients.
- ▶ Upfront gemcitabine-based chemoradiation in select patients.^{9,10}

• Options include:

- ▶ RT 45–54 Gy in 1.8–2.5 Gy fractions (doses higher than 54 Gy may be considered if clinically appropriate) or
- ▶ 36 Gy in 2.4 Gy fractions.¹¹

- Following chemoradiation, additional maintenance chemotherapy is sometimes used, especially if tumors are still unresectable.
- In cases where 1) it is highly unlikely that patients will become resectable (complete encasement of superior mesenteric/celiac arteries); 2) there are suspicious metastases; and 3) patients may not be able to tolerate chemoradiation, then it may be reasonable to start with chemotherapy (2–6 cycles) followed by definitive chemoradiation if there is no evidence of metastatic progression.
- If patients present with poorly controlled pain or local obstructive symptoms, it may be preferable to start with upfront chemoradiation.
- No standard total dose or dose per fraction has been established for SBRT; therefore, it should preferably be utilized as part of a clinical trial.¹²

Adjuvant:^b

- Treatment options following pancreaticoduodenectomy or distal pancreatectomy include:

- ▶ Gemcitabine or CI 5-FU (1 cycle) followed by CI 5-FU/RT followed by maintenance gemcitabine or CI 5-FU.¹⁴
 - ▶ Gemcitabine or bolus 5-FU/leucovorin or continuous infusion 5-FU.¹⁵
 - ▶ Gemcitabine or bolus 5-FU/leucovorin for 2–6 cycles followed by fluoropyrimidine- (CI 5-FU or capecitabine) based chemoradiation.¹⁶
- RT 45–46 Gy in 1.8–2 Gy fractions to the tumor bed, surgical anastomoses (hepaticojejunostomy and gastrojejunostomy may be omitted if clinically appropriate), and adjacent lymph nodes, followed by an additional 5–9 Gy to the tumor bed and anastomoses, if clinically appropriate.¹⁷

Palliative:

- [See Principles of Palliation and Supportive Care \(PANC-E\).](#)

- ▶ RT alone to the primary tumor plus a margin (typically 25–36 Gy in 2.4–5 Gy fractions) is reasonable for patients with metastatic disease who require local palliation for obstruction, pain, or bleeding.¹⁸
- ▶ Palliative RT can also be considered for patients who are elderly and/or not candidates for definitive therapy because of comorbidities.
- ▶ Metastatic sites causing pain may also be palliated with RT.

[Continued on next page](#)

^aBased on preliminary data from the LAP-07 trial, there is no clear survival benefit with the addition of conventional chemoradiation following gemcitabine monotherapy. Chemoradiation may improve local control and delay the need for resumption therapy. (Huguet F, Hammel P, Vernerey D, et al. Impact of chemoradiation on local control and time without treatment in patients with locally advanced pancreatic cancer included in the international phase III LAP 07 study. J Clin Oncol 2014; 32:5s. Abstract 4001.)

^bAdjuvant options listed apply only to patients who did not receive prior neoadjuvant therapy. For those who received prior neoadjuvant therapy, the adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.

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**PRINCIPLES OF RADIATION THERAPY****Radiation Therapy Treatment Planning Principles:**

- Patients should undergo a CT simulation (thin slices through the pancreas/bed and locoregional nodal basins) with IV (assuming adequate kidney function) and oral contrast. For resected cases, preoperative CT scans and strategically placed surgical clips are used to determine the tumor bed, ideally with the surgeon's assistance. In the neoadjuvant, borderline, and locally advanced settings the pancreatic gross tumor volume (GTV) and pathologic nodes (minimum >1 cm) are contoured with assistance from structural (CT/MRI) and functional imaging (PET).^{19,20}
- The planning target volume (PTV) should be defined per the ICRU-62 guidelines.²¹ A GTV should be defined for intact pancreatic tumors. For adjuvant cases, a clinical target volume (CTV) includes high-risk peri-pancreatic lymph nodes, anastomoses (hepaticojejunostomy and gastrojejunostomy may be omitted if clinically appropriate), pancreatic tumor bed derived from presurgical imaging, and strategically placed surgical clips. CTV expansions are needed to include possible microscopic disease. Further expansion to PTV includes internal target volume (ITV) for target/breathing motion and additional patient setup error margin (SM).²²⁻²⁴ Image guidance methods should be considered when constructing the PTV. Organs at risk (OARs) should also be contoured and evaluated in the dose-volume histogram (DVH).
- Elective nodal irradiation (ENI) is commonly used for adjuvant cases but is controversial for unresectable/neoadjuvant/borderline resectable cases.¹¹ Standard margin expansions for unresectable cases include the gross tumor and any pathologic lymph nodes (GTV) plus a 0.5–1.5 cm margin to target microscopic extension (CTV) and an additional 0.5–2 cm volume to account for tumor/breathing motion and patient setup errors (PTV). With these expansions, peripancreatic nodes are generally included.
- 3-D conformal RT (3D-CRT) or intensity-modulated RT (IMRT) with breathhold/gating techniques can result in improved PTV coverage with decreased dose to OARs.^{25,26} With SBRT, smaller margins are used (0.2–0.5 cm) and the PTV does not cover locoregional elective nodal regions.²⁷ If small GTV margin expansions are used for CTV and PTV, breathing motion and setup error should be evaluated or controlled per the AAPM Task Group 76 guidelines.²⁸
- IORT is delivered with electron beam RT (IOERT) or high-dose-rate brachytherapy (HDR-IORT). IORT is generally delivered in a single fraction and in combination with adjuvant or neoadjuvant chemoradiation. The role of IORT is controversial and should only be performed at specialized centers. It is sometimes used in cases where surgical resection may result in close or involved margins.²⁹
- It is imperative to evaluate the DVH of the PTV and critical normal structures such as the liver, kidneys, spinal cord, liver, and bowel.
- ([See Table 1. Normal Tissue Dose Volume Recommendations \[PANC-F, 4 of 6\]](#)) While these examples of limits are empirical they differ based on dose per fraction, total dose delivered, and disease status (adjuvant vs. unresectable). Studies have shown that the tolerability of radiation is largely dependent on PTV size/ENI, types of concurrent systemic/targeted therapy, and whether conformal (3-D, IMRT, SBRT) vs. conventional radiation is used.

[Continued on next page](#)**Note:** All recommendations are category 2A unless otherwise indicated.**Clinical Trials:** NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

**PRINCIPLES OF RADIATION THERAPY**

- Fractionated RT is typically delivered as 30–55 Gy over ~3–6 weeks (1.8–3.0 Gy/fraction, using lower dose per fraction at higher cumulative doses while respecting normal tissue constraints) with concurrent 5-FU/capecitabine or gemcitabine as a radiosensitizer. Doses above 55 Gy may be possible in select cases; however, data are limited and normal tissue dose limits (see Table 1) should be maintained. For resected cases, 45 Gy is delivered to the tumor bed, surgical anastomosis (hepaticojejunostomy and gastrojejunostomy may be omitted if clinically appropriate), and regional lymph nodes. Additional radiation (~5–15 Gy) may be administered to the tumor bed/area of involved margins and anastomoses paying careful attention to dose to bowel and stomach. The use of high-energy photon beams is preferred. SBRT is often delivered in 1–5 fractions ranging from 5–25 Gy per fraction. IORT can be delivered in a single fraction alone (15–20 Gy) or in combination with external beam RT (EBRT) (10–20 Gy).
- Several clinical trials (RTOG) now refer to atlases to assist with contouring and adjuvant RT planning.
<http://www.rtog.org/CoreLab/ContouringAtlases.aspx>.

Table 1: Normal Tissue Dose Volume Recommendations

Structure	Unresectable/Preoperative Recommendations ^c	Adjuvant/Resected Recommendations ^d
Kidney (right and left)	Not more than 30% of the total volume can receive ≥18 Gy. If only one kidney is functional, not more than 10% of the volume can receive ≥18 Gy.	If two functioning kidneys present, not more than 50% of the right and 65% of the left kidney should receive >18 Gy. For IMRT planning mean dose to bilateral kidneys should be ≤18 Gy. If only one kidney is present not more than 15% should receive ≥18 Gy and no more than 30% should receive ≥14 Gy.
Stomach, duodenum, jejunum	Max dose ≤55 Gy; not more than 30% of the volume can be between 45 and 55 Gy.	Max dose ≤55 Gy; <10% of each organ volume can receive between 50–53.99 Gy. <15% of each organ volume can receive 45–49.99 Gy.
Liver	Mean dose cannot exceed 30 Gy.	Mean liver dose ≤25 Gy.
Spinal cord	Max dose to a volume of at least 0.03 cc must be ≤45 Gy.	Max dose ≤45 Gy.

^cAdapted from RTOG 0936 (3-D conformal, 1.8-50.5) and RTOG 1102 (IMRT, 2.2 to 55 Gy)^dAdapted from RTOG 0848 (3-D or IMRT)[Continued on next page](#)**Note:** All recommendations are category 2A unless otherwise indicated.**Clinical Trials:** NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.



NCCN Guidelines Version 2.2016

Pancreatic Adenocarcinoma

PRINCIPLES OF RADIATION THERAPY

Table 2: Commonly Used Radiation Therapy Abbreviations

3D-CRT	3-D Conformal Radiation Therapy
IMRT	Intensity-Modulated Radiation Therapy
SBRT	Stereotactic Body Radiation Therapy
SABR	Stereotactic Ablative Radiation Therapy
EBRT	External Beam Radiation Therapy
ENI	Elective Nodal Irradiation
IORT	Intraoperative Radiation Therapy
DVH	Dose-Volume Histogram
GTV	Gross Tumor Volume
CTV	Clinical Target Volume
IM	Internal Margin: Variations in shape/size of CTV due to respiration and adjacent structures
ITV	Internal Target Volume: encompasses the CTV and IM (ITV = CTV + IM)
PTV	Planning Target Volume
BED	Biologically Effective Dose
OAR	Organ At Risk
ABC	Airway Breathing Control
IGRT	Image-Guided Radiation Therapy
4DCT	Four-Dimensional Computed Tomography
CBCT	Cone Beam Computed Tomography

[Continued on next page](#)

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PRINCIPLES OF RADIATION THERAPY**References**

- ¹Pawlik TM, Laheru D, Hruban RH, et al. Evaluating the impact of a single-day multidisciplinary clinic on the management of pancreatic cancer. *Ann Surg Oncol* 2008 Aug; 15(8): 2081-2088.
- ²White RR, Hurwitz HI, Morse MA, et al. Neoadjuvant chemoradiation for localized adenocarcinoma of the pancreas. *Ann Surg Oncol* 2001 Dec; 8(10): 758-765.
- ³Le Scodan R, Mornex F, Girard N, et al. Preoperative chemoradiation in potentially resectable pancreatic adenocarcinoma: Feasibility, treatment effect evaluation and prognostic factors, analysis of the SFRO-FFCD 9704 trial and literature review. *Ann Oncol* 2009 Aug; 20(8): 1387-1396.
- ⁴Evans DB, Varadhachary GR, Crane CH, et al. Preoperative gemcitabine-based chemoradiation for patients with resectable adenocarcinoma of the pancreatic head. *J Clin Oncol* 2008 Jul 20; 26(21): 3496-3502.
- ⁵Varadhachary GR, Wolff RA, Crane CH, et al. Preoperative gemcitabine and cisplatin followed by gemcitabine-based chemoradiation for resectable adenocarcinoma of the pancreatic head. *J Clin Oncol* 2008 Jul 20; 26(21): 3487-3495.
- ⁶Talamonti MS, Small W, Jr, Mulcahy MF, et al. A multi-institutional phase II trial of preoperative full-dose gemcitabine and concurrent radiation for patients with potentially resectable pancreatic carcinoma. *Ann Surg Oncol* 2006 Feb; 13(2): 150-158.
- ⁷Krishnan S, Rana V, Janjan NA, et al. Induction chemotherapy selects patients with locally advanced, unresectable pancreatic cancer for optimal benefit from consolidative chemoradiation therapy. *Cancer* 2007 Jul 1; 110(1): 47-55.
- ⁸Huguet F, Girard N, Guerche CS, et al. Chemoradiotherapy in the management of locally advanced pancreatic carcinoma: A qualitative systematic review. *J Clin Oncol* 2009 May 1; 27(13): 2269-2277.
- ⁹Blackstock AW, Tepper JE, Niedwiecki D, et al. Cancer and leukemia group B (CALGB) 89805: Phase II chemoradiation trial using gemcitabine in patients with locoregional adenocarcinoma of the pancreas. *Int J Gastrointest Cancer* 2003; 34(2-3): 107-116.
- ¹⁰Loehrer PJ Sr, Feng Y, Cardenes H, et al. Gemcitabine alone versus gemcitabine plus radiotherapy in patients with locally advanced pancreatic cancer: an Eastern Cooperative Oncology Group trial. *J Clin Oncol* 2011 Nov 1; 29(31):4105-12.
- ¹¹Murphy JD, Adusumilli S, Griffith KA, et al. Full-dose gemcitabine and concurrent radiotherapy for unresectable pancreatic cancer. *Int J Radiat Oncol Biol Phys* 2007 Jul 1; 68(3): 801-808.
- ¹²Chang DT, Schellenberg D, Shen J, et al. Stereotactic radiotherapy for unresectable adenocarcinoma of the pancreas. *Cancer* 2009 Feb 1; 115(3): 665-672.
- ¹³Further evidence of effective adjuvant combined radiation and chemotherapy following curative resection of pancreatic cancer. gastrointestinal tumor study group. *Cancer* 1987 Jun 15; 59(12): 2006-2010.
- ¹⁴Regine WF, Winter KA, Abrams RA, et al. Fluorouracil vs gemcitabine chemotherapy before and after fluorouracil-based chemoradiation following resection of pancreatic adenocarcinoma: A randomized controlled trial. *JAMA* 2008 Mar 5; 299(9): 1019-1026.
- ¹⁵Neoptolemos JP, Stocken DD, Bassi C, et al. Adjuvant chemotherapy with fluorouracil plus folinic acid vs gemcitabine following pancreatic cancer resection: a randomized controlled trial. *JAMA* 2010;304:1073-1081.
- ¹⁶Van Laethem JL, Hammel P, Mornex F, et al. Adjuvant gemcitabine alone versus gemcitabine-based chemoradiotherapy after curative resection for pancreatic cancer: A randomized EORTC-40013-22012/FFCD-9203/GERCOR phase II study. *J Clin Oncol* 2010 Oct 10; 28(29): 4450-4456. PMID: PMC2988636.
- ¹⁷Herman JM, Swartz MJ, Hsu CC, et al. Analysis of fluorouracil-based adjuvant chemotherapy and radiation after pancreaticoduodenectomy for ductal adenocarcinoma of the pancreas: Results of a large, prospectively collected database at the Johns Hopkins hospital. *J Clin Oncol* 2008 Jul 20; 26(21):3503-3510.
- ¹⁸Zimmermann FB, Jeremic B, Lersch C, et al. Dose escalation of concurrent hypofractionated radiotherapy and continuous infusion 5-FU-chemotherapy in advanced adenocarcinoma of the pancreas. *Hepatogastroenterology*. 2005 Jan-Feb; 52(61): 246-250.
- ¹⁹Ford EC, Herman J, Yorke E, Wahl RL. 18F-FDG PET/CT for image-guided and intensity-modulated radiotherapy. *J Nucl Med* 2009 Oct; 50(10):1655-1665.
- ²⁰Schellenberg D, Quon A, Minn AY, et al. 18Fluorodeoxyglucose PET is prognostic of progression-free and overall survival in locally advanced pancreas cancer treated with stereotactic radiotherapy. *Int J Radiat Oncol Biol Phys* 2010 Aug 1; 77(5): 1420-1425.
- ²¹J, Bridier A. Definition of volumes in external radiotherapy: ICRU reports 50 and 62]. *Cancer Radiother* 2001 Oct; 5(5): 472-478.
- ²²Minn AY, Schellenberg D, Maxim P, et al. Pancreatic tumor motion on a single planning 4D-CT does not correlate with intrafraction tumor motion during treatment. *Am J Clin Oncol* 2009 Aug; 32(4):364-8.
- ²³Goldstein SD, Ford EC, Duhon M, et al. Use of respiratory-correlated four-dimensional computed tomography to determine acceptable treatment margins for locally advanced pancreatic adenocarcinoma. *Int J Radiat Oncol Biol Phys* 2010 Feb 1; 76(2): 597-602.
- ²⁴Feng M, Balter JM, Normolle D, et al. Characterization of pancreatic tumor motion using cine MRI: Surrogates for tumor position should be used with caution. *Int J Radiat Oncol Biol Phys* 2009 Jul 1; 74(3): 884-891. PMID: PMC2691867.
- ²⁵Spalding AC, Jee KW, Vineberg K, et al. Potential for dose-escalation and reduction of risk in pancreatic cancer using IMRT optimization with lexicographic ordering and gEUD-based cost functions. *Med Phys* 2007 Feb; 34(2): 521-529.
- ²⁶Yovino S, Poppe M, Jabbour S, et al. Intensity-modulated radiation therapy significantly improves acute gastrointestinal toxicity in pancreatic and ampullary cancers. *Int J Radiat Oncol Biol Phys* 2011 Jan 1; 79(1): 158-162.
- ²⁷Koong AC, Christofferson E, Le QT, et al. Phase II study to assess the efficacy of conventionally fractionated radiotherapy followed by a stereotactic radiosurgery boost in patients with locally advanced pancreatic cancer. *Int J Radiat Oncol Biol Phys* 2005 Oct 1; 63(2): 320-323.
- ²⁸Keall PJ, Mageras GS, Balter JM, et al. The management of respiratory motion in radiation oncology report of AAPM task group 76. *Med Phys* 2006 Oct; 33(10): 3874-3900.
- ²⁹Crane CH, Beddar AS, Evans DB. The role of intraoperative radiotherapy in pancreatic cancer. *Surg Oncol Clin N Am* 2003 Oct; 12(4): 965-977.

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**PRINCIPLES OF CHEMOTHERAPY (1 of 3)**

- **Systemic therapy is used in the neoadjuvant or adjuvant setting and in the management of locally advanced unresectable and metastatic disease.**
- **Goals of systemic therapy should be discussed with patients prior to initiation of therapy, and enrollment in a clinical trial is strongly encouraged.**
- **Close follow-up of patients undergoing chemotherapy is indicated.**

Metastatic

- **Acceptable chemotherapy combinations for patients with good performance status include:**
 - ▶ **FOLFIRINOX¹ (category 1) (preferred)**
 - ▶ **Gemcitabine + albumin-bound paclitaxel² (category 1) (preferred)**
 - ▶ **Gemcitabine + erlotinib³ (category 1)^a**
 - ▶ **Gemcitabine + capecitabine⁴**
 - ▶ **Gemcitabine + cisplatin⁵ (Can be considered as an alternative to FOLFIRINOX in patients with possible hereditary cancers involving DNA repair mutations.)**
 - ▶ **Fixed-dose-rate gemcitabine, docetaxel, capecitabine (GTX regimen)⁶ (category 2B)**
 - ▶ **Fluoropyrimidine + oxaliplatin (category 2B) (eg, 5-FU/leucovorin/oxaliplatin⁷ or CapeOx⁸)**
- **Acceptable monotherapy options for patients with poor performance status include:**
 - ▶ **Gemcitabine at 1000 mg/m² over 30 minutes, weekly for 3 weeks every 28 days (category 1).**
 - ▶ **Fixed-dose-rate gemcitabine (10 mg/m²/min) may substitute for standard infusion of gemcitabine over 30 minutes (category 2B).**
 - ▶ **Capecitabine or continuous infusion 5-FU (category 2B)**
- **Second-line chemotherapy may consist of:**
 - ▶ **5-FU + leucovorin + liposomal irinotecan (category 1)¹³ (for metastatic disease previously treated with gemcitabine-based therapy)**
 - ▶ **Gemcitabine-based therapy for those previously treated with fluoropyrimidine-based therapy**
 - ▶ **Fluoropyrimidine-based therapy for those previously treated with gemcitabine-based therapy**

Locally Advanced

- **Depending on performance status, mono- or combination systemic chemotherapy, as noted above, may be considered as initial therapy prior to chemoradiation for appropriate patients with locally advanced, unresectable disease^b. Patients should be evaluated for recovery from hematologic and non-hematologic toxicity prior to initiation of chemoradiation. Patients who progress with metastatic disease are not candidates for chemoradiation unless required for palliative purposes.**

[See Adjuvant, and Neoadjuvant PANC-G \(2 of 3\)](#)[See References on PANC-G \(3 of 3\)](#)^aAlthough this combination significantly improved survival, the actual benefit was small, suggesting that only a small subset of patients benefit.^bBased on preliminary data from the LAP-07 trial, there is no clear survival benefit with the addition of conventional chemoradiation following gemcitabine monotherapy.¹²**Note: All recommendations are category 2A unless otherwise indicated.****Clinical Trials: NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.**



PRINCIPLES OF CHEMOTHERAPY (2 of 3)

Adjuvant

- The CONKO 001 trial demonstrated significant improvements in disease-free survival and overall survival with use of postoperative gemcitabine as adjuvant chemotherapy versus observation in resectable pancreatic adenocarcinoma.⁹
- ESPAC-3 study results showed no significant difference in overall survival between 5-FU/leucovorin versus gemcitabine following surgery. When the groups receiving adjuvant 5-FU/leucovorin and adjuvant gemcitabine were compared, median survival was 23.0 months and 23.6 months, respectively.¹⁰
- The use of gemcitabine-based chemotherapy is frequently combined, sequentially, with 5-FU-based chemoradiotherapy.
- No significant differences were observed in the RTOG 97-04 study comparing pre- and post-chemoradiation 5-FU with pre- and post-chemoradiation gemcitabine for postoperative adjuvant treatment.¹¹
- For patients with good performance status who relapse after receiving adjuvant therapy, FOLFIRINOX or gemcitabine + albumin-bound paclitaxel are options depending on the length of time since completion of adjuvant therapy.
- Recommended adjuvant therapy options apply to patients who did not receive prior neoadjuvant therapy. For those who received prior neoadjuvant therapy, the adjuvant therapy options are dependent on the response to neoadjuvant therapy and other clinical considerations.

Neoadjuvant

- There is limited evidence to recommend specific neoadjuvant regimens off-study, and practices vary with regard to the use of chemotherapy and chemoradiation. Acceptable regimens include FOLFIRINOX or gemcitabine + albumin-bound paclitaxel. Subsequent chemoradiation is sometimes included. Most NCCN Member Institutions prefer neoadjuvant therapy at a high-volume center.

[See Metastatic and Locally Advanced PANC-G \(1 of 3\)](#)

[See References on PANC-G \(3 of 3\)](#)

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PRINCIPLES OF CHEMOTHERAPY (3 of 3)

References

- ¹Conroy T, Desseigne F, Ychou M, et al. FOLFIRINOX versus gemcitabine for metastatic pancreatic cancer. *N Engl J Med* 2011;364:1817-1825.
- ²Von Hoff DD, Ervin T, Arena FP, et al. Increased survival in pancreatic cancer with nab-paclitaxel plus gemcitabine. *N Engl J Med* 2013; 369:1691-1703.
- ³Moore MJ, Goldstein D, Hamm J, et al. Erlotinib plus gemcitabine compared with gemcitabine alone in patients with advanced pancreatic cancer. A phase III trial of the National Cancer Institute of Canada Clinical Trials Group. *J Clin Oncol* 2007;25:1960-1966.
- ⁴Cunningham D, Chau I, Stocken DD, et al. Phase III randomized comparison of gemcitabine (GEM) versus gemcitabine plus capecitabine (GEM-CAP) in patients with advanced pancreatic cancer. *J Clin Oncol* 2009; 27:5513-5518.
- ⁵Oliver GR, Sugar E, Laheru D, et al. Family history of cancer and sensitivity to platinum chemotherapy in pancreatic adenocarcinoma [abstract]. Presented at: 2010 ASCO Gastrointestinal Cancers Symposium; January 22-24, 2010; Orlando, Florida. Abstract 180.
- ⁶Fine RL, Fogelman DR, Schreiber SM, et al. The gemcitabine, docetaxel, and capecitabine (GTX) regimen for metastatic pancreatic cancer: a retrospective analysis. *Cancer Chemother Pharmacol* 2008;61:167-175.
- ⁷Pelzer U, Schwaner I, Stieler J, et al. Best supportive care (BSC) versus oxaliplatin, folinic acid and 5-fluorouracil (OFF) plus BSC in patients for second-line advanced pancreatic cancer: a phase III-study from the German CONKO-study group. *Eur J Cancer* 2011;47:1676-1681.
- ⁸Xiong HQ, Varadhachary GR, Blais JC, et al. A phase II trial of oxaliplatin plus capecitabine (xelox) as second-line therapy for patients with advanced pancreatic cancer. *Cancer* 2008; 113:2046-2052.
- ⁹Oettle H, Neuhaus P, Hochhaus A, et al. Adjuvant chemotherapy with gemcitabine and long-term outcomes among patients with resected pancreatic cancer: the CONKO-001 randomized trial. *JAMA* 2013;310(14):1473-1481.
- ¹⁰Neoptolemos J, Stocken DD, Bassi C, et al. Adjuvant chemotherapy with fluorouracil plus folinic acid vs gemcitabine following pancreatic cancer resection: a randomized controlled trial. *JAMA* 2010;304:1073-1081.
- ¹¹Regine WF, Winter KA, Abrams RA, et al. Fluorouracil vs. gemcitabine chemotherapy before and after fluorouracil-based chemoradiation following resection of pancreatic adenocarcinoma. a randomized controlled trial. *JAMA* 2008; 299:1019-1026.
- ¹²Hammel P, Huguet F, van Laethem J-L, et al: Comparison of chemoradiotherapy and chemotherapy in patients with a locally advanced pancreatic cancer controlled after 4 months of gemcitabine with or without erlotinib: Final results of the international phase III LAP 07 study. 2013 ASCO Annual Meeting. Abstract LBA4003.
- ¹³Wang-Gillam A, Li CP, Bodoky G, et al. Nanoliposomal irinotecan with fluorouracil and folinic acid in metastatic pancreatic cancer after previous gemcitabine-based therapy (NAPOLI-1): a global, randomised, open-label, phase 3 trial. *Lancet* 2016 Feb 6;387(10018):545-57.

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NCCN Guidelines Version 2.2016 Staging Pancreatic Adenocarcinoma

Table 1**American Joint Committee on Cancer (AJCC) TNM Staging of Pancreatic Cancer (2010)**

Because only a few patients with pancreatic cancer undergo surgical resection of the pancreas (and adjacent lymph nodes), a single TNM classification must apply to both clinical and pathologic staging.

Primary Tumor (T)

TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma in situ*
T1	Tumor limited to the pancreas, 2 cm or less in greatest dimension
T2	Tumor limited to the pancreas, more than 2 cm in greatest dimension
T3	Tumor extends beyond the pancreas but without involvement of the celiac axis or the superior mesenteric artery
T4	Tumor involves the celiac axis or the superior mesenteric artery (unresectable primary tumor)

* This also includes the “PanInIII” classification.

Regional Lymph Nodes (N)

NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Regional lymph node metastasis

Distant Metastases (M)

M0	No distant metastases
M1	Distant metastasis

Stage Grouping

Stage 0	Tis	N0	M0
Stage IA	T1	N0	M0
Stage IB	T2	N0	M0
Stage IIA	T3	N0	M0
Stage IIB	T1	N1	M0
	T2	N1	M0
	T3	N1	M0
Stage III	T4	Any N	M0
Stage IV	Any T	Any N	M1

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NCCN Guidelines Version 2.2016 Pancreatic Adenocarcinoma

Discussion

NCCN Categories of Evidence and Consensus

Category 1: Based upon high-level evidence, there is uniform NCCN consensus that the intervention is appropriate.

Category 2A: Based upon lower-level evidence, there is uniform NCCN consensus that the intervention is appropriate.

Category 2B: Based upon lower-level evidence, there is NCCN consensus that the intervention is appropriate.

Category 3: Based upon any level of evidence, there is major NCCN disagreement that the intervention is appropriate.

All recommendations are category 2A unless otherwise noted.

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Pancreatic Adenocarcinoma

Overview

During the year 2016 in the United States, an estimated 53,070 people will be diagnosed with pancreatic cancer, and approximately 41,780 people will die of pancreatic cancer.¹ This disease is the fourth most common cause of cancer-related death among U.S. men (after lung, prostate, and colorectal cancer) and women (after lung, breast, and colorectal cancer).¹ Although incidence is roughly equal in both sexes, African Americans have a higher incidence of pancreatic cancer than white Americans.^{2,3} Furthermore, the incidence of pancreatic cancer in the United States increased from 1999 to 2008, possibly because of the increasing prevalence of obesity, an aging population, and other unknown factors.³⁻⁵ Mortality rates have remained largely unchanged.^{6,7}

In these NCCN Guidelines for Pancreatic Adenocarcinoma, the diagnosis and management of adenocarcinomas of the exocrine pancreas are discussed; neuroendocrine tumors are not included (please see the NCCN Guidelines for Neuroendocrine Tumors, available at www.NCCN.org). These NCCN Guidelines are intended to assist with clinical decision-making, but they cannot incorporate all possible clinical variations and are not intended to replace good clinical judgment or individualization of treatments. Exceptions to the rule were discussed among the panel members during the process of developing and updating these guidelines. A 5% rule (omitting clinical scenarios that comprise less than 5% of all cases) was used to eliminate uncommon clinical occurrences or conditions from these guidelines. A study of 3706 patients treated for pancreatic cancer in large California hospitals showed that compliance with these NCCN Guidelines for Pancreatic Adenocarcinoma, defined very permissively, improves survival.⁸

As an overall guiding principle of these guidelines, the panel believes that decisions about diagnostic management and resectability of pancreatic cancer should involve multidisciplinary consultation at high-volume centers with use of appropriate imaging studies. In addition, the panel believes that increasing participation in clinical trials (only 4.6% of patients enroll in a pancreatic cancer trial⁹) is critical to making progress in this disease. Thus, the panel unanimously endorses participation in a clinical trial over standard or accepted therapy.

Literature Search Criteria and Guidelines Update Methodology

Prior to the update of this version of the NCCN Guidelines for Pancreatic Adenocarcinoma, an electronic search of the PubMed database was performed to obtain key literature in the field of pancreatic cancer published between July 29, 2014 and July 20, 2015, using the following search terms: (pancreatic cancer) OR (pancreatic adenocarcinoma) OR (pancreas adenocarcinoma) OR (pancreas cancer). The PubMed database was chosen because it remains the most widely used resource for medical literature and indexes only peer-reviewed biomedical literature.¹⁰

The search results were narrowed by selecting studies in humans published in English. Results were confined to the following article types: Clinical Trial, Phase II; Clinical Trial, Phase III; Clinical Trial, Phase IV; Practice Guideline; Guidelines; Randomized Controlled Trial; Meta-Analysis; Systematic Reviews; and Validation Studies.

The PubMed search resulted in 152 citations, and their potential relevance was examined. The data from key PubMed articles and articles from additional sources deemed as relevant to these Guidelines and discussed by the panel have been included in this version of the Discussion section (eg, e-publications ahead of print, meeting

abstracts). Recommendations for which high-level evidence is lacking are based on the panel's review of lower-level evidence and expert opinion.

The complete details of the Development and Update of the NCCN Guidelines are available on the NCCN website (www.NCCN.org).

Risk Factors and Genetic Predisposition

Although the increase in risk is small, pancreatic cancer is firmly linked to cigarette smoking.¹¹⁻¹⁶ Exposure to chemicals and heavy metals such as beta-naphthylamine, benzidine, pesticides, asbestos, benzene, and chlorinated hydrocarbons is associated with increased risk for pancreatic cancer,^{17,18} as is heavy alcohol consumption.^{11,13,19-21}

An increased body mass index (BMI) is associated with an increased risk for pancreatic cancer,^{19,22-24} with BMI during early adulthood being associated with increased pancreatic cancer mortality.²⁵ A meta-analysis including 22 cohort studies with 8,091 patients with pancreatic cancer showed that those who engage in low levels of physical activity have an increased risk for pancreatic cancer, relative to those who engage in high levels of physical activity (RR, 0.93; 95% CI, 0.88–0.98).²⁶ Regarding diet, there is some evidence that increased consumption of red/processed meat and dairy products is associated with an elevation in pancreatic cancer risk,^{27,28} although other studies have failed to identify dietary risk factors for the disease.^{15,29,30} The association between tea consumption and pancreatic cancer risk has been examined, with mostly null associations being found. A meta-analysis including 14 studies showed that regular tea consumption is associated with a lower risk for pancreatic cancer in Chinese populations (RR, 0.76; 95% CI, 0.59–0.98; $P = .036$) and in those >60 years (RR, 0.76; 95% CI, 0.60–0.96, $P = .023$).³¹ A meta-analysis focusing on green tea consumption that included three case-control and

five prospective studies from China and Japan failed to show a statistically significant association with pancreatic cancer risk.³²

Studies examining the association between vitamin D and risk for pancreatic cancer have shown contradictory results. Some data suggest that low plasma 25-hydroxyvitamin D levels may increase the risk for pancreatic cancer.³³ A recent pooled analysis of nine case-control studies, including 2,963 patients with pancreatic cancer and 8,527 control subjects, showed a positive association between vitamin D intake and pancreatic cancer risk (OR, 1.13; 95% CI, 1.07–1.19; $P < .001$).³⁴ This association may be stronger in those with low retinol/Vitamin A intake.

Chronic pancreatitis has been identified as a risk factor for pancreatic cancer,³⁵⁻³⁸ with one study demonstrating a 7.2-fold increased risk for pancreatic cancer for patients with a history of pancreatitis.³⁹ A meta-analysis including two case-control studies and one cohort study (1,636 patients with pancreatic cancer) showed that hepatitis B infection is associated with pancreatic cancer (OR, 1.50; 95% CI, 1.21–1.87).⁴⁰ Overall, further epidemiologic studies involving careful evaluation of these possible risk factors with adjustments for potential confounders are needed to clarify their impact on pancreatic cancer risk.

Diabetes and Pancreatic Cancer

The association between diabetes mellitus and pancreatic cancer is particularly complicated. A population-based study of 2122 patients with diabetes found that approximately 1% of patients diagnosed with diabetes who are age 50 years or younger will be diagnosed with pancreatic cancer within 3 years.⁴¹ Prediabetes may also be associated with increased risk for pancreatic cancer.⁴² A recent systematic review and dose-response meta-analysis including nine prospective studies ($N = 2,408$) showed that every 0.56 mmol/L increase in fasting blood



glucose is associated with a 14% increase in pancreatic cancer incidence.⁴³

Numerous studies have shown an association between new-onset non-insulin-dependent diabetes and the development of pancreatic cancer,^{41,44-47} especially in those who are elderly, have a lower BMI, experience weight loss, or do not have a family history of diabetes.⁴⁸ In these short-onset cases of diabetes diagnosed prior to pancreatic cancer diagnoses, diabetes is thought to be caused by the cancer, although the physiologic basis for this effect is not yet completely understood.⁴⁹

Long-term diabetes, on the other hand, appears to be a risk factor for pancreatic cancer, as some studies have shown an association of pancreatic cancer with diabetes of 2- to 8-year duration.⁵⁰ However, certain risk factors such as obesity, associated with both diabetes and pancreatic cancer, may confound these analyses.⁵¹

The use of diabetic medications has been reported to alter pancreatic cancer risk.⁵² The use of insulin or sulfonylureas has been found to be associated with an increased risk for pancreatic cancer.⁵³⁻⁵⁵ On the other hand, metformin may be associated with a reduced risk for pancreatic and other cancers,⁵³⁻⁵⁸ though a retrospective cohort study ($N = 980$) showed that metformin did not significantly improve survival in diabetic patients diagnosed with pancreatic cancer.⁵⁹

In addition, diabetes and diabetic medication may affect outcomes in patients with pancreatic cancer. Metformin use has been reported to result in higher pancreatic cancer survival in diabetics. A retrospective analysis of 302 patients with pancreatic cancer and diabetes treated at The University of Texas MD Anderson Cancer Center found that metformin use was associated with increased survival at 2 years (30.1%

vs. 15.4%; $P = .004$) and increased overall survival (OS, 15.2 months vs. 11.1 months; $P = .009$).⁶⁰ The OS difference was significant only in patients without distant metastases and remained significant when insulin users were excluded. In contrast, data from a recent meta-analysis of >38,000 patients show that those with pancreatic cancer and diabetes have a significantly lower OS than those without diabetes (14.4 vs. 21.7 months; $P < .001$).⁴⁶ A similar result was seen in a prospective cohort study, in which the survival of 504 patients with and without diabetes who developed pancreatic cancer in the Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial was compared.⁶¹ After multivariable adjustment, mortality was significantly higher in participants with diabetes compared to those without (hazard ratio [HR], 1.52; 95% CI, 1.14–2.04; $P < .01$).

Genetic Predisposition

Pancreatic cancer is thought to have a familial component in approximately 10% of cases, and familial excess of pancreatic cancer is associated with high risk.^{15,62-65} A prospective registry-based study of 5179 individuals from 838 kindreds found that having just 1 first-degree relative with pancreatic cancer raises the risk for pancreatic cancer by 4.6-fold, whereas having 2 affected first-degree relatives raises the risk by about 6.4-fold.⁶⁶ The genetic basis of this inherited predisposition is not known in most cases, and as many as 80% of patients with a family history of pancreatic cancer have no known genetic cause.⁶² However, some familial cancer syndromes are associated with an increased risk for pancreatic cancer (see *Table 1*, below).

Germline mutations in the *STK11* gene result in Peutz-Jeghers syndrome, in which individuals have gastrointestinal polyps and a highly elevated risk for colorectal cancer.⁶⁷⁻⁶⁹ These individuals also have a highly elevated risk for developing pancreatic cancer, reported to be

increased by as much as 132-fold.^{70,71} Furthermore, *STK11* undergoes somatic mutation in approximately 5% of pancreatic cancers.⁷²

As with non-hereditary forms of pancreatitis, familial pancreatitis is also associated with an increased risk for pancreatic cancer.⁷³ Several genes are associated with the familial form of pancreatitis, including *PRSS1*, *SPINK1*, and *CFTR*.⁷⁴ The increased risk for the development of pancreatic cancer in these individuals is estimated to be 26-fold to as high as 87-fold.^{36,75-77}

Familial Malignant Melanoma syndrome (also known as Melanoma-Pancreatic Cancer syndrome or Familial Atypical Multiple Mole Melanoma [FAMMM]) syndrome is caused by germline mutation of the *CDKN2A* (p16INK4a/p14ARF) gene.⁷⁸ This syndrome is associated with a 20-fold to 47-fold increased risk for pancreatic cancer.^{79,80} In addition, patients with Melanoma-Pancreatic Cancer syndrome may experience an earlier onset of pancreatic cancer than the general population.⁸¹ In an analysis of 515 probands with a family history of pancreatic cancer, 2.5% had a germline mutation in *CDKN2A*, while 7.8% of probands with a family history of both pancreatic cancer and melanoma ($n = 77$) had this genetic mutation.⁸² In a sample of 178 *CDKN2A* mutation carriers undergoing surveillance at three expert centers in Europe, pancreatic cancer was detected in 7.3%.⁸³ In an unselected series of 225 patients with pancreatic cancer in Italy, 5.7% had mutations in *CDKN2A*.⁸⁴

Lynch syndrome is the most common form of genetically determined colorectal cancer predisposition and is caused by germline mutations in DNA mismatch repair (MMR) genes (*MLH1*, *MSH2*, *MSH6*, or *PMS2*).⁸⁵⁻⁹⁰ Patients with Lynch syndrome also have an estimated 9- to 11-fold elevated risk for pancreatic cancer.^{91,92} In a sample of 96 patients with pancreatic cancer, two mutations were found in the *MSH6* MMR gene.⁹³

An excess of pancreatic cancer is also seen in families harboring *BRCA1/2* (breast cancer susceptibility gene-1 and -2) mutations, although the link with *BRCA2* is better established.^{82,93-99} Studies of unselected patients with pancreatic cancer have detected *BRCA1/2* mutations at a frequency of 4% to 7%.^{100,101} The risk for pancreatic cancer is elevated 2- to 6-fold in these patients, and the age of onset is younger than average in the general population.^{94,98,99} Patients with pancreatic cancer who have Ashkenazi Jewish ancestry may have a greater likelihood of testing positive for a *BRCA1/2* mutation, with prevalence of detected mutations in this group ranging from 5.5% to 19%, with mutations being more common for *BRCA2*.^{96,101-103}

BRCA1/2 is also involved in the Fanconi DNA anemia/*BRCA* pathway. This pathway is responsible for the repair of DNA interstrand cross-links, and particular mutations in other Fanconi anemia/*BRCA* pathway genes, including in *PALB2*, *FANCC*, and *FANCG*, have also been identified as increasing pancreatic cancer susceptibility.^{82,104-106}

Whole-genome sequencing allowed for the identification of germline mutations in *ATM*, a DNA damage response gene, in 2 kindreds with familial pancreatic cancer.¹⁰⁷ Further analyses then revealed *ATM* mutations in 4 of 166 individuals with familial pancreatic cancer. In a sample of 96 patients with pancreatic cancer, 4% had a mutation in *ATM*.⁹³

Patients with pancreatic cancer for whom a hereditary cancer syndrome is suspect should be considered for genetic counseling.¹⁰⁸ The panel emphasizes the importance of taking a thorough family history when seeing a new patient with pancreatic cancer. In particular, a family history of pancreatitis, melanoma, and cancers of the pancreas, colorectum, breast, and ovaries should be noted. A free online pancreatic cancer risk prediction tool, called PancPRO, is available and

may help determine risk.⁶⁵ Referral for genetic counseling may be considered for patients diagnosed with pancreatic cancer who have a family history of cancer or who are young. If a cancer syndrome is identified, at-risk relatives should be offered genetic counseling. With or without a known syndrome, individuals with a suspicious family history should be advised on risk-reducing strategies including smoking cessation and weight loss. In addition, the possibility of screening for pancreatic (see below) and other cancers should be discussed.

Premalignant Tumors of the Pancreas

Mucinous cystic neoplasms (MCNs) and intraductal papillary mucinous neoplasms (IPMNs) of the pancreas are cystic lesions that can be small and asymptomatic and are often discovered incidentally; MCNs have an ovarian-like stroma.¹⁰⁹⁻¹¹¹ IPMNs can occur in the main duct and/or in the branch ducts. Lesions involving the main duct have a higher malignant potential than those in the branches, with the risk of malignancy at around 62%.¹¹² The risk of malignancy in MCNs is <15%.¹¹²

An international group of experts has established guidelines for the management of pancreatic IPMNs and MCNs,¹¹² as has a European group.¹¹³ The international group strongly recommends resection in fit patients with main duct IPMNs.¹¹² For branch-duct IPMNs, surveillance is considered an appropriate option in patients who are older or unfit or for cysts lacking suspicious features. Branch-duct IPMNs that are ≥10 mm, have an enhancing solid component, or are in the head of the pancreas causing obstructive jaundice should be considered for resection.¹¹² Patients with resected IPMNs are followed with imaging studies to identify recurrences. For MCNs, the international group recommends resection for all fit patients, and recurrences are not observed.¹¹² The European group gives similar recommendations.¹¹³

Pancreatic Cancer Screening

Asymptomatic individuals at high risk for pancreatic cancer (ie, those with first-degree relatives with pancreatic cancer) were assessed using endoscopic ultrasound (EUS) in the Cancer of the Pancreas Screening 2 (CAPS2) project.¹¹⁴ Preinvasive pancreatic neoplasms were detected in 10% of high-risk patients, suggesting that EUS may have a promising role in screening high-risk patients. The CAPS Consortium reported results of its CAPS3 study, in which 225 asymptomatic high-risk individuals were independently (in a blinded manner) screened once with CT, MRI, and EUS.¹¹⁵ In this study, 42% of individuals were found to have an abnormality; 5 individuals underwent surgical interventions, 3 of whom had high-grade dysplasia in small IPMNs and intraepithelial neoplasias. When results of the 3 screening modalities were compared, EUS detected abnormalities in 42% of individuals, versus 33% and 11% for MRI and CT, respectively.

Interestingly, results from a prospective cohort study that followed high-risk individuals for an average of 4.2 years showed that, although 32% of 262 participants were found to have pancreatic abnormalities, and some IPMNs and intraepithelial neoplasias were resected, 3 patients developed pancreatic adenocarcinoma (2 metastatic, 1 recurrent 30 months post-resection) despite screening.¹¹⁶ These results could be due to rapid malignant progression, but they are more likely a result of inadequate imaging by MRI.

The diagnostic yield of pancreatic cancer screening with EUS in asymptomatic individuals at high risk for familial disease was also investigated in the Netherlands,¹¹⁷ while a German study used EUS plus MRI/magnetic resonance cholangiopancreatography (MRCP) in a similar high-risk population.¹¹⁸ Although results from these trials seem promising overall, the malignant potential of some preinvasive

pancreatic lesions and the impact of screening on survival are presently unclear. Results suggest that MRI/MRCP may be a useful adjunct or a noninvasive alternative to EUS for pancreatic cancer screening.

Newer screening methods to identify patients with early pancreatic cancer rather than those with preinvasive lesions may prove to be beneficial in the future. Examples of techniques being investigated are microRNA biomarkers in whole blood and serum metabolism profiling.¹¹⁹⁻¹²² In addition, circulating cell-free DNA is being investigated as a possible biomarker for screening. One study showed that methylation patterns in cell-free plasma DNA can differentiate between pancreatitis and pancreatic cancer with a sensitivity of 91.2% and specificity of 90.8%.¹²³ In addition, CA 19-9 levels may be elevated in patients up to 2 years before a pancreatic cancer diagnosis, indicating that CA 19-9 has potential as a biomarker for screening high-risk patients.¹²⁴

An international CAPS Consortium summit with 49 multidisciplinary experts was held in 2011 to develop consensus guidelines for pancreatic cancer screening.¹²⁵ The group recommends screening with EUS and/or MRI/MRCP for high-risk individuals, defined as first-degree relatives of patients with pancreatic cancer from familial kindreds; carriers of *p16* or *BRCA2* mutations with an affected first-degree relative; patients with Peutz-Jeghers syndrome; and patients with Lynch syndrome and an affected first-degree relative with pancreatic cancer. The group also concluded that more evidence is needed regarding optimal management of patients with detected lesions, the age to begin screening, and screening intervals.

Diagnosis and Staging

Ductal adenocarcinoma and its variants account for over 90% of pancreatic malignancies. The presenting symptoms of this disease can

include weight loss, jaundice, floating stools, pain, dyspepsia, nausea, and depression; however, no early warning signs of pancreatic cancer have been established. As previously noted, sudden onset of adult type 2 diabetes in patients 50 years or older may be linked to a new diagnosis of pancreatic cancer; patients with long-standing diabetes may also develop pancreatic cancer (see *Diabetes and Pancreatic Cancer*, above). Thus, pancreatic carcinoma should be considered in diabetic patients with unusual manifestations, such as abdominal symptoms and continuous weight loss.

Unlike many other cancers, imaging is the primary means through which the stage of pancreatic cancer is determined. High-quality multi-phase imaging can help to preoperatively distinguish between patients eligible for resection with curative intent and those with unresectable disease. The criteria for defining resectable disease favor specificity over sensitivity to avoid denying surgery to patients with a potentially resectable tumor.¹²⁶ All patients for whom there is clinical suspicion of pancreatic cancer or evidence of a dilated duct (stricture) should therefore undergo initial evaluation by CT performed according to a dedicated pancreas protocol.¹²⁷ In addition, the panel recommends imaging after neoadjuvant treatment to provide adequate staging and assessment of resectability status. Subsequent decisions regarding diagnostic management and resectability should involve multidisciplinary consultation, with use of appropriate studies to evaluate the extent of disease. The panel recommends that a multidisciplinary review ideally involve expertise from surgery, diagnostic imaging, interventional endoscopy, medical oncology, radiation oncology, and pathology.

The AJCC has developed staging criteria for adenocarcinoma of the pancreas that follow the tumor/node/metastasis (TNM) system.¹²⁸ Although the TNM staging criteria for pancreatic cancer in the 7th edition

of the AJCC Cancer Staging Manual have taken into account the fact that tumors of the pancreas are evaluated preoperatively by CT or MRI to determine resectability status, these staging criteria also include information that can be determined only through postsurgical pathologic evaluation of resected tumor.^{128,129} Validation of concordance between AJCC stage and OS has been provided through evaluation of 121,713 patients with pancreatic adenocarcinoma included in the National Cancer Data Base (NCDB).¹²⁹

For clinical purposes, however, most NCCN Member Institutions use a clinical classification system based mainly on results of presurgical imaging studies. Following staging by pancreatic protocol CT (and EUS and/or MRI/MRCP or endoscopic retrograde cholangiopancreatography [ERCP] in some cases), liver function tests, and chest imaging, disease is classified as: 1) resectable; 2) borderline resectable (ie, tumors that are involved with nearby structures so as to be neither clearly resectable nor clearly unresectable with a high chance of an R1 resection); 3) locally advanced unresectable (ie, tumors that are involved with nearby structures to an extent that renders them unresectable despite the absence of evidence of metastatic disease); or 4) disseminated, and this system is used throughout the guidelines. See *Criteria for Resection* below for more detailed definitions.

Imaging Evaluations

Pancreatic Protocol CT and MRI

Multi-detector CT angiography, performed by acquiring thin, preferably sub-millimeter, axial sections using a dual-phase pancreatic protocol, with images obtained in the pancreatic and portal venous phase of contrast enhancement, is the preferred imaging tool for dedicated pancreatic imaging. Scan coverage can be extended to cover the chest and pelvis for complete staging as per institutional preferences. Multiplanar reconstruction is preferred as it allows precise visualization

of the relationship of the primary tumor to the mesenteric vasculature as well as detection of subcentimeter metastatic deposits.^{126,127,130} Studies have shown that 70% to 85% of patients determined by CT imaging to have resectable tumors were able to undergo resection.^{126,131-135} However, the sensitivity of CT for small hepatic and peritoneal metastases is limited.

The difference in contrast enhancement between the parenchyma and adenocarcinoma is highest during the late arterial phase, thereby providing a clear distinction between a hypodense lesion in the pancreas and the rest of the organ. A multi-phasic pancreatic protocol also allows for selective visualization of important arterial (eg, celiac axis, superior mesenteric artery [SMA], peripancreatic arteries) and venous structures (eg, superior mesenteric vein [SMV], splenic vein, portal vein [PV]), thereby providing an assessment of vascular invasion by the tumor. All of this information can improve the prediction of resectability. Software allowing for 3-D reconstruction of imaging data can provide additional valuable information on the anatomic relationship between the pancreatic tumor and the surrounding blood vessels and organs, and multiplanar reconstruction is preferred. However, further development of this technology may be needed before it is routinely integrated into clinical practice.¹³⁴

Patients commonly present to the oncologist with a non-pancreas protocol CT already performed. The panel feels that if the CT scan is of high quality, it can be sufficient. If not, a pancreas protocol CT is recommended. Such selective reimaging was shown to change the staging and management of patients with pancreatic adenocarcinoma in 56% of cases retrospectively reviewed at one institution.¹³⁶

Pancreas protocol MRI can be a helpful adjunct to CT in the staging of pancreatic cancer, particularly for characterization of CT-indeterminate

liver lesions and when suspected pancreatic tumors are not visible on CT or in cases of contrast allergy.^{137,138}

Recently, a multidisciplinary expert consensus group defined standardized language for the reporting of imaging results.¹²⁷ Such uniform reporting can help improve the accuracy and consistency of staging to determine optimal treatment strategies for individual patients and can allow cross-study and cross-institutional comparisons for research purposes. Use of the template also ensures a complete assessment and reporting of all imaging criteria essential for optimal staging and can therefore aid in determining optimal management. The use of the radiology staging reporting template is thus recommended by the panel. The template recommended by the panel includes morphologic, arterial, venous, and extrapancreatic evaluations.¹²⁷ The morphologic evaluation includes documentation of tumor appearance, size, and location, as well as the presence of narrowing or abrupt cut-off of pancreatic duct or biliary tree. The arterial evaluation should include assessment of the celiac axis, the superior mesenteric artery, and the common hepatic artery. Arterial variations should also be noted, such as vessel contact, solid soft-tissue contact, hazy attenuation or stranding contact, and focal vessel narrowing or contour irregularity. Venous evaluation should include an assessment of the main portal vein and the SMV. Documentation of thrombus within the vein and venous collaterals should also be done. The extrapancreatic evaluation should include documentation of liver lesions, peritoneal or omental nodules, ascites, suspicious lymph nodes, and other present extrapancreatic disease sites.

Endoscopic Ultrasound

NCCN Member Institutions vary in the use of additional staging technologies, such as EUS. An analysis of 20 studies and 726 cases of pancreatic cancer showed that EUS for T1-2 staging has a sensitivity

and specificity of 0.72 and 0.90, respectively.¹³⁹ Sensitivity and specificity for T3-4 staging is 0.90 and 0.72, respectively. The role of EUS in staging is felt to be complementary to CT, providing additional information for patients whose initial scans show no lesion or whose lesions have questionable involvement of blood vessels or lymph nodes.¹⁴⁰⁻¹⁴³ In particular, EUS may provide assessment of certain types of vascular invasion.^{144,145} The sensitivity and specificity values for nodal staging (0.62 and 0.74, respectively) are lower than the values for vascular invasion (0.87 and 0.92, respectively).¹³⁹ It is the consensus of the panel that while the accuracy of EUS in assessing the involvement of certain veins (eg, PV) is high, this technique is less accurate in imaging tumor invasion of the SMA.¹⁴⁶ Therefore, EUS is not recommended as a routine staging tool.

EUS is also used to discriminate between benign and malignant strictures or stenosis, because severe stenosis and marked proximal dilatation most often indicate malignancy.¹⁴⁷ EUS can also be used to evaluate periampullary masses, separating invasive from noninvasive lesions. In addition, EUS plays a role in better characterizing cystic pancreatic lesions due to the ability to aspirate the cyst contents for cytologic, biochemical, and molecular analysis. On EUS, malignant cystic lesions may present as a hypoechoic cystic/solid mass or as a complex cyst, and they are frequently associated with a dilated main pancreatic duct. Some therapeutic interventions can also be done with EUS (eg, celiac neurolysis, removal of ascites). Because this procedure is operator dependent, some divergence in use may occur because of differing technical capabilities and available expertise.

Endoscopic Retrograde Cholangiopancreatography and MRI/Magnetic Resonance Cholangiopancreatography

ERCP is a technique that combines endoscopic and fluoroscopic procedures and is generally limited to therapeutic interventions.¹⁴⁸ In the

guidelines, ERCP with duct brushing cytology is recommended as clinically indicated for patients without a mass in the pancreas and without evidence of metastatic disease who require biliary decompression and who undergo additional imaging with EUS to help establish a diagnosis.¹⁴⁹ Thus from a therapeutic standpoint, ERCP allows for stent placement and can be used to palliate biliary obstruction when surgery is not elected or if surgery must be delayed.

MRI/MRCP is considered to be equivalent to EUS/ERCP in the diagnostic setting; brushings can be obtained with either. MRI/MRCP can also be performed with secretin to increase secretion of pancreatic juices from the proximal pancreas for better delineation of a pancreatic duct that has a subtle stricture.¹⁵⁰

PET/CT

The utility of PET/CT for upstaging patients with pancreatic cancer has also been evaluated. In a retrospective study, the use of PET/CT following a standard CT protocol showed increased sensitivity for detection of metastatic disease when compared with the standard CT protocol or PET/CT alone.¹⁵¹ The sensitivity of detecting metastatic disease for PET/CT alone, standard CT alone, and the combination of PET/CT and standard CT were 61%, 57%, and 87%, respectively. In this study, the clinical management of 11% of patients with invasive pancreatic cancer was changed as a result of PET/CT findings. Nevertheless, the role of PET/CT in this setting is evolving and has not yet been established.^{152,153} PET/CT is not a substitute for high-quality contrast-enhanced CT, although it can be considered as an adjunct to a formal pancreatic CT protocol in high-risk patients. Indicators of high risk for metastatic disease may include borderline resectable disease, markedly elevated carbohydrate antigen (CA) 19-9, large primary tumors, large regional lymph nodes, and patients who are very symptomatic.

Laparoscopy

Laparoscopy is another potentially valuable diagnostic tool for staging; it can identify peritoneal, capsular, or serosal implants or studding of metastatic tumor on the liver that may be missed even with the use of a pancreatic CT protocol.¹⁵⁴⁻¹⁵⁶ The yield of laparoscopy is dependent on the quality of preoperative imaging and the likelihood of metastatic disease. A key goal is to avoid unnecessary laparotomy, which can be accomplished in an estimated 23% of patients in whom curative intent surgery is planned,¹⁵⁵ although routine use of staging laparoscopy is controversial. The panel does not consider staging laparoscopy to be a substitute for poor-quality preoperative imaging.

Some evidence provides support for a selective approach to staging laparoscopy (ie, it is performed if the presence of occult metastatic disease is suggested by high-quality imaging or certain clinical indicators).¹⁵⁷ For example, preoperative serum CA 19-9 levels >100 U/mL or >215 U/mL (see discussion of *Biomarkers*, below) have been associated with a greater likelihood of advanced disease and an increased probability of a positive finding on staging laparoscopy.^{158,159} In a prospective review of 838 patients who were diagnosed with resectable pancreatic tumors on imaging evaluation between 1999 and 2005, 14% were found to have unresectable disease (21% yield if only pancreatic adenocarcinoma was considered) following subsequent laparoscopy.¹⁶⁰ Characteristics associated with an increased laparoscopic yield of unresectable disease include the location of the tumor, tumor histology, the presence of weight loss and jaundice, and the facility conducting the imaging evaluation.

Diagnostic staging laparoscopy to rule out metastases not detected on imaging (especially for patients with body and tail lesions) is used routinely in some NCCN Member Institutions prior to surgery or



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Pancreatic Adenocarcinoma

chemoradiation, or selectively in patients who are at higher risk for disseminated disease (ie, borderline resectable disease; markedly elevated CA 19-9; large primary tumors; large regional lymph nodes; highly symptomatic). Thus, the panel believes that staging laparoscopy can be considered for patients staged with resectable pancreatic cancer who are considered to be at increased risk for disseminated disease and for patients with borderline resectable disease prior to administration of neoadjuvant therapy. Intraoperative ultrasound may be used as a diagnostic adjunct during staging laparoscopy to further evaluate the liver and tumor and vascular involvement. The panel considers positive cytology from washings obtained at laparoscopy or laparotomy to be equivalent to M1 disease.¹⁶¹

Biopsy

Although a pathologic diagnosis is not required before surgery, it is necessary before administration of neoadjuvant therapy and for patients staged with locally advanced, unresectable pancreatic cancer or metastatic disease. A pathologic diagnosis of adenocarcinoma of the pancreas is often made using fine-needle aspiration (FNA) biopsy with either EUS guidance (preferred) or CT. EUS-FNA is preferable to CT-guided FNA in patients with resectable disease because of better diagnostic yield, safety, and potentially lower risk of peritoneal seeding with EUS-FNA when compared with the percutaneous approach.¹⁶²⁻¹⁶⁴ Additional risks of CT-directed FNA biopsy include the potential for greater bleeding and infection because of the need to traverse vessels and bowel. EUS-FNA also gives the benefit of additional staging information at the time of biopsy.

EUS-FNA is highly accurate and reliable for determining malignancy. A recent retrospective analysis of 317 patients with EUS-FNA results from 2 institutions found that 97% of cases deemed malignant were in fact

malignant on clinical follow-up.¹⁶⁵ In contrast, 13% of cases that were classified as benign were actually malignant. In rare cases when EUS-FNA cannot be obtained from a patient with borderline resectable or unresectable disease, other acceptable methods of biopsy exist. For instance, intraductal biopsies can be obtained via endoscopic cholangioscopy.¹⁶⁶ A percutaneous approach¹⁶³ or a laparoscopic biopsy¹⁶⁷ are other alternatives. Pancreatic ductal brushings or biopsies can also be obtained at the time of ERCP, often revealing malignant cytology consistent with pancreatic adenocarcinoma.

If a biopsy does not confirm malignancy, at least 1 repeat biopsy should be performed; EUS-FNA with or without a core biopsy at a center with multidisciplinary expertise is preferred. Alternative diagnoses including autoimmune pancreatitis should be considered (see *Differential Diagnoses*, below). A positive biopsy is required before administration of chemotherapy. However, it is important to reiterate that biopsy proof of malignancy is not required before surgical resection for clearly resectable or borderline resectable disease and that a nondiagnostic biopsy should not delay surgical resection when the clinical suspicion for pancreatic cancer is high. The NCCN Pancreatic Adenocarcinoma Panel strongly recommends that all diagnostic and surgical management decisions involve multidisciplinary consultation.

Evolving changes in molecular analyses of pancreatic cancer have led some institutions to attempt to procure additional tumor-rich, formalin-fixed, paraffin-embedded tissue to bank for future genomic studies. Several methods can be used to obtain such tissue samples, including core biopsy, but the panel believes that core biopsies should not replace EUS-FNA, but rather can be done in addition to EUS-FNA. Some of the most common somatic mutations in pancreatic cancer are *KRAS*, *TP53*, *CDKN2A*, and *SMAD4*.^{168,169} Molecularly targeted therapies for pancreatic cancer are being developed and investigated.¹⁷⁰

Biomarkers

Many tumor-associated antigens have been studied in connection with pancreatic adenocarcinoma, including carcinoembryonic antigen (CEA), pancreatic anti-oncofetal antigen, tissue polypeptide antigen, CA 125, and CA 19-9. The panel recognizes the importance of identifying biomarkers for early detection of this difficult disease, and they emphasize the need for collection and sharing of tissue to help accelerate the discovery of prognostic biomarkers (see *Future Clinical Trials: Recommendations for Design*, below). For example, a meta-analysis including eight studies found that S100 calcium-binding protein P (S100P) shows high sensitivity (0.87; 95% CI, 0.83–0.90) and specificity (0.88; 95% CI, 0.82–0.93) for diagnosis of pancreatic cancer.¹⁷¹

CA 19-9

The best validated and most clinically useful biomarker for early detection and surveillance of pancreatic cancer is CA 19-9, a sialylated Lewis A blood group antigen. CA 19-9 is commonly expressed and shed in pancreatic and hepatobiliary disease and in many malignancies; thus, it is not tumor-specific. However, the degree of increase in CA 19-9 levels may be useful in differentiating pancreatic adenocarcinoma from inflammatory conditions of the pancreas (see *Differential Diagnoses*, below).¹⁷² CA 19-9 has potential uses in diagnosis, in screening, in staging, in determining resectability, as a prognostic marker after resection, and as a predictive marker for response to chemotherapy.¹⁷³

CA 19-9 is a good diagnostic marker, with sensitivity of 79% to 81% and specificity of 80% to 90% in symptomatic patients,¹⁷⁴ but its low positive predictive value makes it a poor biomarker for screening.¹⁷⁵

Preoperative CA 19-9 levels correlate with both AJCC staging and resectability and thus can provide additional information for staging and

determining resectability, along with information from imaging, laparoscopy, and biopsy.¹⁷⁶⁻¹⁷⁸

CA 19-9 also seems to have value as a prognostic and a predictive marker for pancreatic cancer in various settings. In resectable disease, for instance, low postoperative serum CA 19-9 levels or a serial decrease in CA 19-9 levels following surgery have been found to be prognostic for survival for patients undergoing resection.^{175,176,178-184} In a prospective study of patients undergoing surgery with curative intent, median survival for the group of patients with post-resectional CA 19-9 levels of <180 U/mL was significantly higher compared with the group with higher levels of CA 19-9 following surgery (HR, 3.53; $P < .0001$).¹⁸⁰

Also in the resectable setting, data from an analysis of 260 consecutive patients support the predictive role of postoperative CA 19-9 levels for benefit of adjuvant therapy.¹⁸³ Among patients with CA 19-9 levels of <90 U/mL, those who received adjuvant therapy (mostly gemcitabine-based) had a longer disease-free survival (DFS) than those who did not (26.0 months vs. 16.7 months; $P = .011$). In contrast, patients with higher CA 19-9 levels did not appear to benefit from adjuvant therapy, with DFS of 16.2 months and 9.0 months for those receiving or not receiving adjuvant therapy, respectively ($P = .719$). In this same study, the 11 patients with post-adjuvant therapy CA 19-9 levels <37 U/mL did not die of pancreatic cancer, while the 8 patients with increased CA 19-9 levels post-adjuvant therapy had a median DFS of 19.6 months, suggesting a possible prognostic benefit of post-adjuvant therapy CA 19-9 levels in this setting.

In the neoadjuvant/borderline resectable setting, a recent study of 141 patients treated at MD Anderson Cancer Center found that post-treatment CA 19-9 levels were a good prognostic marker in patients receiving neoadjuvant therapy with or without subsequent resection.¹⁸⁵

This study found that a normalization of CA 19-9 to <40 U/mL was associated with improvements in OS in non-resected (15 months vs. 11 months; $P = .02$) and resected (38 months vs. 26 months; $P = .02$) disease.

In the advanced disease setting, data support the role of CA 19-9 as a prognostic marker.^{179,186,187} In a prospective study of patients with advanced pancreatic cancer, pretreatment CA 19-9 serum levels were shown to be an independent prognostic factor for survival.¹⁸⁶ In addition, the change in CA 19-9 levels during chemotherapy in patients with advanced disease has been shown to be useful for evaluating the benefit of treatment, although the data are not entirely consistent.¹⁸⁶⁻¹⁹¹ For example, a recent study that pooled individual patients' data from 6 prospective trials found that a decline in CA 19-9 levels from baseline to after surgery and 2 rounds of adjuvant therapy were associated with a better outcome.¹⁷⁹ In fact, increases of <5% in CA 19-9 were also associated with improved outcomes compared to patients with larger increases (OS, 10.3 months vs. 5.1 months; $P = .002$).

It is important to note that CA 19-9 may be undetectable in Lewis antigen-negative individuals.¹⁹² Furthermore, CA 19-9 may be falsely positive in cases of biliary infection (cholangitis), inflammation, or biliary obstruction (regardless of etiology) and do not necessarily indicate cancer or advanced disease.^{193,194} Preoperative measurement of CA 19-9 levels (category 3) is therefore best performed after biliary decompression is complete and bilirubin is normal. If biliary decompression is not performed in a patient with jaundice, CA 19-9 levels can be assessed (category 3), but they do not represent an accurate baseline.

The panel recommends measurement of serum CA 19-9 levels prior to surgery (category 3), following surgery immediately prior to

administration of adjuvant therapy, and for surveillance (category 2B). The panel emphasizes the importance of obtaining a CA 19-9 measurement immediately before the therapeutic intervention to have an accurate baseline from which to follow response; for example, before and after neoadjuvant therapy in patients with tumors that are borderline resectable. Of note, a number of different methods are commercially available for quantifying this tumor-associated antigen. Measurements of serum levels of CA 19-9 using one testing method cannot be extrapolated to results obtained using a different procedure.

Differential Diagnoses

Chronic pancreatitis and other benign conditions are possible differential diagnoses of patients suspected of having pancreatic cancer.¹⁹⁵⁻¹⁹⁹ Autoimmune pancreatitis, a rare form of chronic pancreatitis also known as lymphoplasmacytic sclerosing pancreatitis, is a heterogeneous disease that can present with clinical and radiologic characteristics of pancreatic cancer, such as jaundice, weight loss, an elevated CA 19-9 level, and the presence of diffuse pancreatic enlargement, a pancreatic ductal stricture, or a focal pancreatic mass.^{197,200-202} The classic appearance of the pancreas on abdominal CT in patients with diffuse pancreatic involvement is a sausage-shaped enlargement of the organ with a capsule-like peripheral rim surrounding the pancreas, although focal enlargement of the pancreas is observed in some cases.²⁰¹ Cardinal histologic features of autoimmune pancreatitis include prominent lymphocytic infiltration of the pancreatic parenchyma with associated fibrosis.

In addition, fine-needle aspirates can be misinterpreted as malignant or suspicious for malignancies.^{203,204} As a benign disease that can be effectively treated with corticosteroids, autoimmune pancreatitis must be

distinguished from pancreatic cancer to avoid unnecessary surgery and prevent delay in the initiation of appropriate treatment.²⁰³⁻²⁰⁶

The finding of increased serum immunoglobulin (Ig) G levels is supportive of a diagnosis of autoimmune pancreatitis, although an elevated level of serum IgG4 specifically is the most sensitive and specific laboratory indicator.²⁰⁷ A recent study found that IgG4 levels of >1.0 g/L combined with CA 19-9 levels of <74 U/mL distinguished patients with autoimmune pancreatitis from those with adenocarcinoma with 94% sensitivity and 100% specificity.²⁰⁸ Jaundiced patients with locally advanced disease should be reviewed for autoimmune pancreatitis, and IgG4 levels should be assessed.

Autoimmune pancreatitis can, however, be negative for IgG4, thus closely mimicking pancreatic adenocarcinoma when there is a large pancreatic mass. For patients with borderline resectable disease and cancer not confirmed after 2 or 3 biopsies, a second opinion is recommended. Alternative diagnoses should be considered, especially autoimmune pancreatitis, and a short course of steroid treatment may be an appropriate first approach. If no response is seen, the patient should undergo laparotomy for removal of the mass.

Systemic Therapy Approaches

Systemic therapy is used in all settings of pancreatic adenocarcinoma. It is important that biopsy confirmation of pancreatic adenocarcinoma be obtained before treatment in all cases (see Table 2, below). At least 2 or 3 negative or indeterminate biopsies should be obtained before entertaining alternative diagnoses (see *Differential Diagnoses*, above). A second opinion should also be obtained in such a case. Occasionally, other cancer types are confirmed, and the patient should be treated according to the appropriate NCCN Guideline. The data supporting the regimens used in pancreatic cancer are described below.

Gemcitabine Monotherapy

For patients with locally advanced or metastatic disease, gemcitabine has been established as providing clinical benefit and a modest survival advantage over treatment with bolus 5-FU.²⁰⁹ The panel recommends gemcitabine monotherapy as one option for front-line therapy for patients with metastatic disease (category 1) or locally advanced disease and a good performance status. Because the approved indications for gemcitabine include the relief of symptoms, the panel also recommends gemcitabine monotherapy as a reasonable option for symptomatic patients with metastatic or locally advanced unresectable disease with poor performance status (category 1).

Gemcitabine monotherapy also has category 1 evidence supporting its use in the adjuvant setting. In the large phase III CONKO-001 trial, in which 368 patients without prior chemotherapy or RT were randomly assigned to adjuvant gemcitabine versus observation following macroscopically complete resection, an intention-to-treat (ITT) analysis of the data showed that the primary endpoint of increased DFS was met (13.4 months vs. 6.9 months; $P < .001$, log rank).²¹⁰ Final results from this study showed median OS to be improved significantly for patients in the gemcitabine arm (22.8 months vs. 20.2 months; HR, 0.76; 95% CI, 0.61–0.95; $P = .01$).²¹¹ An absolute survival difference of 10.3% was observed between the two groups at 5 years (20.7% vs. 10.4%).²¹¹

Gemcitabine Response: hENT1

Human equilibrative nucleoside transporter 1 (hENT1) is a nucleoside transporter that has been studied as a predictor for response to gemcitabine.²¹² Preliminary clinical data have shown that hENT1 expression may in fact predict response to gemcitabine.²¹³⁻²¹⁸

hENT1 has been validated in 2 retrospective analyses as a predictive biomarker for benefit from gemcitabine. A recent retrospective analysis

of core tissue from patients treated on the adjuvant gemcitabine ESPAC-3 trial found that hENT1 expression was predictive of response to gemcitabine but not to 5-FU.²¹⁴ Median survival for patients treated with gemcitabine was 17.1 months versus 26.2 months for those with low versus high hENT1 expression, respectively ($P = .002$). In the 5-FU group, median survival was 25.6 months versus 21.9 months for the low and high hENT1 groups, respectively ($P = .36$). A similar analysis was performed on samples of patients treated on RTOG 9704.²¹³ As with the ESPAC-3 study, hENT1 expression was associated with OS (HR, 0.40; 95% CI, 0.22–0.75; $P = .03$) and DFS (HR, 0.39; 95% CI, 0.21–0.73; $P = .003$) in patients receiving gemcitabine, but hENT1 expression was not associated with OS (HR, 0.78; 95% CI, 0.47–1.27; $P = .31$) and DFS (HR, 0.72; 95% CI, 0.45–1.16; $P = .18$) in the group given 5-FU.

Thus, hENT1 appears to be an excellent predictive biomarker in the adjuvant setting based on the assay used in both of these studies (IHC with the 10D7G2 antibody). Other separate retrospective analyses of results from the adjuvant CONKO-001 trial and the AIO-PK0104 trial were unable to confirm these results using a different antibody for the IHC analysis (SP120).^{219,220}

Unfortunately, hENT1 could not be validated in the metastatic setting in the LEAP trial, which also used the SP120 assay to determine hENT1 expression. Results from the phase II, randomized, open-label LEAP trial, which compared a lipid-conjugated form of gemcitabine that does not require hENT1 for cell entry (CO-1.01) with gemcitabine in patients with metastatic disease with high versus low expression of hENT1, found that hENT1 expression was not predictive of outcomes in patients treated with gemcitabine.²²¹ Trial results also found no differences in OS between the 2 treatments in patients with low hENT2 expression (HR, 0.99; 95% CI, 0.75–1.33).

Further studies based on hENT1 expression using the 10D7G2 assay are limited by the fact that no commercial source of the antibody and no CLIA-approved testing are available.

Fixed-Dose-Rate Gemcitabine

Studies have suggested that the infusion rate of gemcitabine may be important for its efficacy. Gemcitabine is a prodrug, which must be phosphorylated for antitumor activity. Clinical studies have shown that administering gemcitabine at a fixed dose rate (FDR) maximizes intracellular concentrations of the phosphorylated forms of gemcitabine.²²² In a randomized phase II trial of patients with locally advanced or metastatic pancreatic cancer, the infusion of gemcitabine at an FDR led to better survival compared with gemcitabine delivered at a higher dose, over 30 minutes.²²³ In the phase III randomized ECOG-6201 trial of patients with advanced pancreatic cancer, median survival was increased in the group receiving FDR gemcitabine vs. standard gemcitabine (6.2 months vs. 4.9 months; $P = .04$), although this outcome did not satisfy the protocol-specified criteria for superiority.²²⁴ When gemcitabine is considered for the treatment of advanced pancreatic cancer, the NCCN Panel views FDR gemcitabine (10 mg/m²/min) as a reasonable alternative to the standard infusion of gemcitabine over 30 minutes (category 2B).

FDR gemcitabine is incorporated into some commonly used gemcitabine-based regimens (eg, GEMOX [gemcitabine, oxaliplatin]; GTX [gemcitabine, docetaxel, and capecitabine]). See *Gemcitabine Combinations*, below.^{225,226} The combination of FDR gemcitabine and capecitabine has also been found to be active and well-tolerated.²²⁷

Gemcitabine Combinations

The NCCN Panel acknowledges that, historically, combination chemotherapy did not appear to be superior to monotherapy in the era



of 5-FU-based therapy. However, because gemcitabine is superior to bolus 5-FU in the advanced setting when efficacy endpoints of survival and relief from symptoms are used, it is now often combined with other chemotherapeutic agents for patients with good performance status. Gemcitabine has been investigated in combination with potentially synergistic agents (such as cisplatin, oxaliplatin, capecitabine, 5-FU, and irinotecan) or in a multidrug combination (eg, cisplatin, epirubicin, gemcitabine, 5-FU).^{224-226,228-238} Two meta-analyses of randomized controlled trials found that gemcitabine combinations give a marginal benefit in OS over gemcitabine monotherapy in the advanced setting, with a significant increase in toxicity.^{239,240}

Combinations recommended in the advanced setting are discussed below. The panel does not consider the combination of gemcitabine plus docetaxel²⁴¹ or gemcitabine plus irinotecan^{238,241,242} to meet the criteria for inclusion in the guidelines. In addition, gemcitabine plus sorafenib is not recommended. The multi-center, double-blind, placebo-controlled, randomized phase III BAYPAN trial compared gemcitabine plus either sorafenib or placebo in chemotherapy-naïve patients with advanced or metastatic disease.²⁴³ This trial did not meet its primary endpoint of progression-free survival (PFS) in its 104 patients (5.7 months vs. 3.8 months; $P = .90$). Gemcitabine combinations are currently being studied in the adjuvant setting.

Of note, results from several studies have indicated that the benefit of gemcitabine combination chemotherapy is predominantly seen in patients with good performance status.^{232,233,235}

Gemcitabine Plus Albumin-Bound Paclitaxel

Albumin-bound paclitaxel is a nanoparticle form of paclitaxel. In a publication of a phase I/II trial, 67 patients with advanced pancreatic cancer received gemcitabine plus albumin-bound paclitaxel. At the

maximum tolerated dose, the partial response rate was 48%, with an additional 20% of patients demonstrating stable disease for ≥ 16 weeks. The median OS at this dose was 12.2 months.²⁴⁴

Based on these results, the large, open-label, international, randomized phase III MPACT trial was initiated in 861 patients with metastatic pancreatic cancer and no prior chemotherapy.²⁴⁵ Participants were randomized to receive gemcitabine plus albumin-bound paclitaxel or gemcitabine alone. The trial met its primary endpoint of OS (8.7 months vs. 6.6 months; $P < .0001$; HR, 0.72).^{245,246} The addition of albumin-bound paclitaxel also improved other endpoints, including 1-year survival, 2-year survival, response rate, and PFS. Overall survival was associated with a decrease in CA 19-9 (HR, 0.53; 95% CI, 0.36–0.78; $P = .001$).²⁴⁷ Tumor response was validated with PET imaging.²⁴⁸ The most common grade 3 or higher adverse events attributable to albumin-bound paclitaxel were neutropenia, fatigue, and neuropathy. Updated results of the MPACT trial show that long-term survival is possible with gemcitabine plus albumin-bound paclitaxel, as 3% of patients from that arm were alive at 42 months, whereas no patients were alive from the control arm at that time.²⁴⁹ Factors associated with survival in this trial include KPS score and absence of liver metastases.²⁵⁰

For the 2013 guidelines, the panel upgraded the combination of gemcitabine plus albumin-bound paclitaxel from a category 2B to a category 1 recommendation for the treatment of patients with metastatic disease and good performance status based on these results, and it is listed as a preferred option in this setting. Good performance status for this regimen is defined as KPS ≥ 70 ,²⁴⁹ so some patients with an ECOG score of 2 may be eligible to receive this regimen.^{251,252} By extrapolation of the data, the panel recommends this combination in the locally advanced, good performance status setting as well (category 2A). The

panel also notes that this combination is an acceptable option in the neoadjuvant/borderline resectable setting.

Gemcitabine Plus Erlotinib and Other Targeted Therapeutics

Although phase II trial results of gemcitabine combined with new targeted drugs (eg, bevacizumab, cetuximab) were encouraging,^{253,254} results of phase III studies of combinations of gemcitabine with a biologic agent have indicated that only the combination of gemcitabine plus erlotinib is associated with a statistically significant increase in survival when compared to gemcitabine alone.²⁵⁵⁻²⁵⁹ In the phase III, double-blind, placebo-controlled NCIC CTG PA.3 trial of 569 patients with advanced or metastatic pancreatic cancer randomly assigned to receive erlotinib (which is an inhibitor of EGFR tyrosine kinase) plus gemcitabine versus gemcitabine alone, patients in the erlotinib arm showed statistically significant improvements in OS (HR, 0.82; $P = .038$) and PFS (HR, 0.77; $P = .004$) when compared to patients receiving gemcitabine alone.²⁵⁵ Median survival was 6.24 months and 1-year survival was 23%, compared with 5.91 months and 17% in the control arm. Adverse events, such as rash and diarrhea, were increased in the group receiving erlotinib, but most were grade 1 or 2.²⁵⁵ This trial, other trials, and community experience show that occurrence of grade 2 or higher skin rash is associated with better response and OS of patients receiving erlotinib.^{255,260,261}

Several targeted therapies besides erlotinib have been assessed in combination with gemcitabine, but none have been shown to significantly impact outcomes. Agents assessed in phase III trials include bevacizumab (an anti-vascular endothelial growth factor [VEGF] antibody),^{256,257,259} axitinib,²⁵⁸ ziv-aflibercept,^{262,263} rigosertib (kinase inhibitor),²⁶⁴ and ganitumab (an insulin-like growth factor 1 receptor monoclonal antibody).²⁶⁵ The angiogenesis inhibitor sunitinib was assessed in a phase II randomized trial.²⁶⁶

The NCCN Panel recommends gemcitabine-erlotinib combination therapy as another option for patients with locally advanced or metastatic disease and good performance status, with this combination being a category 1 recommendation for patients with metastatic disease. However, the panel notes that although this combination significantly improved survival, the actual benefit was small, suggesting that only a small subset of patients benefit.

Gemcitabine Plus Cisplatin

Data regarding the survival impact of combining gemcitabine with a platinum agent are conflicting, and results of randomized controlled trials have not provided support for use of gemcitabine plus cisplatin in the treatment of patients with advanced pancreatic cancer. Three phase III trials evaluating the combination of gemcitabine with cisplatin versus gemcitabine alone in patients with advanced pancreatic cancer failed to show a significant survival benefit for the combination over the single agent.^{229,230,233}

Nevertheless, selected patients may benefit from this regimen because patients with breast and ovarian cancers who are carriers of a *BRCA* mutation²⁶⁷⁻²⁶⁹ and selected patients with inherited forms of pancreatic cancer⁹⁶ may have disease that is particularly sensitive to a platinum agent. A retrospective study from Johns Hopkins University School of Medicine of patients with metastatic pancreatic cancer and a family history of breast, ovarian, or pancreatic cancers suggested that response to gemcitabine and cisplatin was superior even with one affected relative.²⁷⁰ Patients with a family history of pancreatic cancer alone demonstrated a large survival advantage when treated with platinum-based chemotherapy (6.3 vs. 22.9 months; HR, 0.34; 95% CI, 0.15–0.74; $P < .01$).²⁷⁰ Furthermore, a report of 5 of 6 patients with known *BRCA* mutations and metastatic pancreatic adenocarcinoma treated with a platinum-based regimen at Memorial Sloan Kettering

Cancer Center showed a radiographic partial response.²⁷¹ Thus, gemcitabine plus cisplatin may be a good choice in selected patients with disease characterized by hereditary risk factors (eg, *BRCA* or *PALB2* mutations). The panel recommends gemcitabine plus cisplatin for patients with metastatic disease, especially as an alternative to FOLFIRINOX in patients with a hereditary cancer syndrome involving a DNA repair mutation.

Gemcitabine Plus Capecitabine

A number of randomized trials have investigated the combination of gemcitabine with capecitabine, a fluoropyrimidine, in patients with advanced pancreatic cancer. A randomized study in 533 patients with advanced disease found that PFS and objective response rates were significantly improved in patients receiving gemcitabine plus capecitabine when compared with gemcitabine alone, although a trend toward an improvement in OS for the combination arm did not reach statistical significance.²³¹ Similarly, results from another smaller phase III trial evaluating this combination did not demonstrate an OS advantage for overall study population receiving the combination of gemcitabine with capecitabine, although a post-hoc analysis showed OS to be significantly increased in the subgroup of patients with good performance status.²³⁵ In a recent meta-analysis of 8 RCTs, OS was better in patients receiving gemcitabine plus capecitabine than in patients receiving gemcitabine alone (HR, 0.87; $P = .03$).²⁷² Although there are concerns about dosing and toxicity of capecitabine in a U.S population, a biweekly regimen of fixed-dose gemcitabine in combination with capecitabine may be both effective and well tolerated in patients with advanced disease.²²⁷

The panel includes the combination of gemcitabine, docetaxel, and capecitabine (GTX regimen) as a category 2B recommendation for the treatment of patients with advanced disease and good performance

status. In a report of 35 patients with metastatic pancreatic cancer treated with this regimen, the authors reported an overall response rate of 29% (all had partial responses), with an additional 31% of patients exhibiting a minor response or stable disease.²²⁶ The median survival was 11.2 months for all patients and 13.5 months for patients exhibiting a partial response. This regimen demonstrated significant toxicities, however, with 14% of patients having grade 3/4 leukopenia, 14% having grade 3/4 thrombocytopenia, and 9% having grade 3/4 anemia. A retrospective case-review study at The Sidney Kimmel Comprehensive Cancer Center at Johns Hopkins found similar results, with a median OS of 11.6 months and grade 3 or greater hematologic and non-hematologic toxicity rates of 41% and 9%, respectively.²⁷³

Gemcitabine combined with capecitabine and oxaliplatin (GEMOXEL) was recently assessed in a randomized phase II trial ($N = 67$) for the metastatic setting.²⁷⁴ Disease control rate ($P = .004$), progression-free survival ($P < .001$), and overall survival ($P < .001$) were all superior in patients randomized to receive the GEMOXEL regimen, compared to patients randomized to receive gemcitabine alone.

The NCCN Panel considers gemcitabine-based combination therapy with capecitabine to be a reasonable option (category 2A) for patients with locally advanced or metastatic disease and a good performance status who are interested in pursuing more aggressive therapy outside a clinical trial.

Gemcitabine and Other Fluoropyrimidine-Based Therapies

Gemcitabine has been examined in combination with other fluoropyrimidine-based therapies. A recent meta-analysis of 8 randomized controlled trials, including >2000 patients, found that OS was significantly improved when a fluoropyrimidine was added to gemcitabine.²⁷² In a phase II randomized trial, the effects of the

FIRGEM regimen [irinotecan delivered before and after infusion of 5-FU/leucovorin (FOLFIRI.3), alternating with fixed-dose-rate gemcitabine] were assessed in 98 patients with metastatic pancreatic cancer.²⁷⁵ Patients were randomized to receive the FIRGEM regimen or fixed-dose-rate gemcitabine monotherapy. The primary objective of a 45% PFS rate at six months was reached, and PFS was a median of 5.0 months in those randomized to receive the FIRGEM regimen, while those randomized to receive only gemcitabine had a median PFS of 3.4 months (HR, 0.59; 95% CI, 0.38–0.90). Rates of hematologic toxicity were higher in those who received the FIRGEM regimen, relative to those who received gemcitabine only. Study investigators deemed FIRGEM to be effective and feasible in the metastatic setting.

The ECOG E2297 trial compared gemcitabine monotherapy with gemcitabine and bolus 5-FU/leucovorin in patients with advanced pancreatic cancer; no statistically significant survival advantage was observed for patients receiving the combination regimen.²²⁸

Recent randomized trials from Asia show that gemcitabine combined with the oral fluoropyrimidine S-1 may improve response and survival in patients with locally advanced pancreatic cancer, though trial results are inconsistent regarding whether outcomes are improved over gemcitabine monotherapy.^{276,277}

5-FU/Leucovorin

5-FU with leucovorin is listed in the guidelines as a category 1 option in the adjuvant setting. Results from the European Study Group for Pancreatic Cancer (ESPAC)-1 trial, reported by Neoptolemos and colleagues, suggested that 5-FU/leucovorin is superior to observation.²⁷⁸ In addition, results from the ESPAC-3 trial of bolus 5-FU/leucovorin versus gemcitabine following surgery showed no

difference in median OS between the arms (23.0 months and 23.6 months, respectively).²⁷⁹

Leucovorin Shortage

There is currently a shortage of leucovorin in the United States. There are no specific data to guide management under these circumstances, and all proposed strategies are empiric. The panel recommends several possible options to help alleviate the problems associated with this shortage. One is the use of levo-leucovorin, which is commonly used in Europe. A dose of 200 mg/m² of levo-leucovorin is equivalent to 400 mg/m² of standard leucovorin. Another option is for practices or institutions to use lower doses of leucovorin for all doses in all patients, since the panel feels that lower doses are likely to be as efficacious as higher doses, based on several studies. The QUASAR study found that 175 mg leucovorin gave similar survival and 3-year recurrence rates as 25 mg leucovorin when given with bolus 5-FU to patients as adjuvant therapy following R0 resections for colorectal cancer.²⁸⁰ Another study showed no difference in response rate or survival in patients with metastatic colorectal cancer receiving bolus 5-FU with either high-dose (500 mg/m²) or low-dose (20 mg/m²) leucovorin.²⁸¹ Also, the Mayo Clinic and North Central Cancer Treatment Group (NCCTG) determined that there was no therapeutic difference between the use of high- (200 mg/m²) or low- (20 mg/m²) dose leucovorin with bolus 5-FU in the treatment of advanced colorectal cancer, although 5-FU doses were different in the 2 arms.²⁸² Finally, if none of the above options is available, treatment without leucovorin would be reasonable. For patients who tolerate this without grade II or higher toxicity, a modest increase in 5-FU dose (in the range of 10%) may be considered.

FOLFIRINOX

In 2003, a French group reported the results of an open phase I study to assess the feasibility of a combination therapy consisting of 5-

FU/leucovorin plus oxaliplatin and irinotecan (FOLFIRINOX) for the treatment of patients with metastatic solid tumors.²⁸³ Their study included 2 patients with pancreatic cancer, and the regimen showed anti-tumor activity. A subsequent multicenter phase II trial specifically for patients with advanced pancreatic adenocarcinoma demonstrated promising response rates.²⁸⁴ A later randomized phase II trial showed a response rate of >30% to FOLFIRINOX in patients with metastatic pancreatic cancer.²⁸⁵

Results from the randomized phase III PRODIGE trial evaluating FOLFIRINOX versus gemcitabine in patients with metastatic pancreatic cancer and good performance status showed dramatic improvements in both median PFS (6.4 months vs. 3.3 months; $P < .001$) and median OS (11.1 months vs. 6.8 months; $P < .001$), in favor of the group receiving FOLFIRINOX.²⁸⁶ Eligibility criteria for this trial, however, were stringent, limiting real-world generalizability.²⁸⁷ For example, patients with abnormal bilirubin levels were excluded from participating.

A systematic review including 11 studies and 315 patients with locally advanced pancreatic cancer showed a pooled median OS of 24.2 months (95% CI, 21.7–26.8).²⁸⁸ A recent observational study including 101 patients with locally advanced unresectable disease who were treated with FOLFIRINOX as induction therapy showed that 29% of the sample (20% without administration of chemoradiation) had a reduction in tumor size of greater than 30%, and half of the patients who experienced a reduction in tumor size underwent resection.²⁸⁹ Out of the patients who underwent resection, 55% achieved an R0 resection. Prospective randomized trials are needed to validate these results.

Because of the strong results from the PRODIGE trial, in 2011 the panel added FOLFIRINOX as a preferred, category 1 recommendation for first-line treatment of patients with good performance status (ie, ECOG

0-1) with metastatic pancreatic cancer. It is listed as a category 2A recommendation for patients with locally advanced unresectable disease by extrapolation. The panel also lists this regimen as an acceptable option in the neoadjuvant/borderline resectable setting.

There are some concerns about the toxicity of the FOLFIRINOX regimen. In the PRODIGE trial, some of the grade 3/4 toxicity rates that were significantly greater in the FOLFIRINOX group than in the gemcitabine group were 45.7% for neutropenia, 12.7% for diarrhea, 9.1% for thrombocytopenia, and 9.0% for sensory neuropathy.²⁸⁶

Despite the high levels of toxicity, no toxic deaths have been reported.²⁸⁴⁻²⁸⁶ Furthermore, the PRODIGE trial determined that, despite this toxicity, fewer patients in the FOLFIRINOX group than in the gemcitabine group experienced a degradation in their quality of life at 6 months (31% vs. 66%, $P < .01$).²⁸⁶ A more detailed analysis of the quality of life of patients in this trial has been published and shows that FOLFIRINOX maintained and even improved quality of life more than gemcitabine did.²⁹⁰

The panel appreciates that toxicity of FOLFIRINOX can be managed with a variety of approaches. For example, a group from Memorial Sloan Kettering Cancer Center reported good activity and acceptable toxicity of first-line FOLFIRINOX at 80% dose intensity with routine growth factor support in carefully selected patients with metastatic or locally advanced disease.²⁹¹ Median OS was 12.5 months in the metastatic setting and 13.7 months in patients with locally advanced disease. The efficacy and toxicity of a modified FOLFIRINOX regimen in which the initial dosing of bolus 5-FU and irinotecan were each reduced by 25% were assessed in a phase II single-arm prospective trial ($N = 75$).²⁹² In patients with metastatic disease, the efficacy of the modified regimen was comparable to that of the standard regimen (median OS = 10.2 months). In patients with locally advanced disease, the median OS



was 26.6 months. Patients who received the modified regimen experienced significantly less neutropenia, fatigue, and vomiting, relative to patients who received the standard FOLFIRINOX regimen.

Capecitabine and Continuous Infusion 5-FU

The panel lists capecitabine monotherapy and continuous infusion 5-FU as first-line treatment options for patients with locally advanced unresectable or metastatic disease (category 2B). They are also recommended as options in the adjuvant settings (category 2A for continuous infusion 5-FU and category 2B for capecitabine). The capecitabine recommendation is supported by a randomized phase III trial from the Arbeitsgemeinschaft Internistische Onkologie (AIO) group in which OS was similar in patients with advanced pancreatic cancer receiving capecitabine plus erlotinib followed by gemcitabine monotherapy or gemcitabine plus erlotinib followed by capecitabine monotherapy.²⁹³

Note that the capecitabine dose recommended by the panel (1000 mg/m² PO twice daily) is less than the dose described by Cartwright and colleagues, because the higher dose has been associated with increased toxicity (eg, diarrhea, hand and foot syndrome).²⁹⁴

Fluoropyrimidine Plus Oxaliplatin

The combination of a fluoropyrimidine (5-FU/leucovorin or capecitabine) with oxaliplatin is listed as a possible first-line treatment for metastatic or locally advanced disease (category 2B). The panel bases these recommendations on the randomized phase III CONKO-003 trial (5-FU/leucovorin/oxaliplatin vs. best supportive care) and on a phase II study (CapeOx).^{295,296} Both of these studies only enrolled patients who had received 1 prior chemotherapy regimen, but the panel feels the extrapolation to first-line therapy is appropriate (category 2B).

Possible Role of Maintenance Therapy in Advanced Disease

With the success of more effective regimens in patients with advanced disease, questions have been raised about how best to manage the treatment-free interval prior to disease progression. Options include stopping treatment, dropping the most toxic agents, and using different agents for maintenance therapy.

A recent randomized phase II trial (PACT-12) had intriguing results that suggest maintenance therapy with sunitinib after a full course of first-line treatment may have a benefit in some patients with metastatic disease.²⁹⁷ Patients without evidence of progression after 6 months of initial therapy (n = 55; mostly gemcitabine combinations) were randomized to sunitinib or observation. Median OS was 9.2 months in the observation group versus 10.6 months in the sunitinib group (HR, 0.71; 95% CI, 0.40–1.26; *P* = .11). The small sample size precludes strong conclusions; however, the 1- and 2-year survival rates were 36% and 7% in the observation arm compared with 41% and 23% in the sunitinib arm, suggesting that a subset of patients derive significant benefit. Anti-angiogenic agents have not been successful in the treatment of pancreatic cancer to date. However, results of the PACT-12 trial suggest that there may in fact be a role for these compounds in this disease. Angiogenesis inhibitors may be more useful after more effective first-line treatments. Clearly additional trials in this important area are needed.

Second-Line Systemic Therapy in the Advanced Setting

A recent systematic review of clinical trials that assessed the efficacy of second-line therapy after gemcitabine in pancreatic cancer concluded that, while data are very limited, evidence suggests an advantage of additional chemotherapy over best supportive care.²⁹⁸ For patients with advanced disease who have received prior gemcitabine-based therapy,

fluoropyrimidine-based chemotherapy regimens are acceptable second-line options.^{295,296,299} Gemcitabine-based therapy can be given to those previously treated with fluoropyrimidine-based therapy.

Results from the phase III CONKO-003 trial presented in 2008 showed significant improvements in both median PFS (13 weeks vs. 9 weeks; $P = .012$) and median OS (20 weeks vs. 13 weeks; $P = .014$) when oxaliplatin was added to 5-FU/leucovorin,^{300,301} making this regimen the standard approach for second-line therapy for patients without prior exposure to fluoropyrimidine-based therapy at that time. Final results of the trial were published in 2014.³⁰² The median OS in the OFF arm was 5.9 months (95% CI, 4.1–7.4), whereas it was 3.3 months (95% CI, 2.7–4.0) in the 5-FU/LV arm, for a significant improvement in the HR (0.66; 95% CI, 0.48–0.91; $P = .01$).

However, results from the open-label phase III PANCREOX trial show that the addition of oxaliplatin to 5-FU/LV in second-line treatment may be detrimental.³⁰³ In this trial, 108 patients with advanced pancreatic cancer who progressed on gemcitabine-based treatment were randomized to receive second-line mFOLFOX6 or infusional 5FU/LV. No difference was seen in median PFS (3.1 vs. 2.9 months; $P = .99$), but median OS was worse in those in the FOLFOX arm (6.1 vs. 9.9 months; $P = .02$). Furthermore, the addition of oxaliplatin resulted in increased toxicity, with rates of grade 3/4 adverse events of 63% in the FOLFOX arm and of 11% in the 5-FU/LV arm.

In the recent NAPOLI-1 phase III randomized trial, the effects of nanoliposomal irinotecan was examined in patients with metastatic pancreatic cancer who previously received gemcitabine-based therapy.³⁰⁴ Patients were randomized to receive the nanoliposomal irinotecan monotherapy, 5-FU/leucovorin, or both ($N = 417$). Median PFS (3.1 months vs. 1.5 months; HR, 0.56; 95% CI, 0.41–0.75; $P <$

.001) was significantly greater for patients who received nanoliposomal irinotecan with 5-FU/leucovorin, compared to patients who did not receive irinotecan. Updated analyses showed that median OS (6.2 months vs. 4.2 months; HR, 0.75; $P = .042$) was significantly greater for patients who received nanoliposomal irinotecan with 5-FU/leucovorin, compared to patients who received 5-FU/leucovorin without irinotecan.³⁰⁵ Grade 3 or 4 adverse events that occurred most frequently with this regimen were neutropenia (27%), fatigue (14%), diarrhea (13%), and vomiting (11%).³⁰⁴ Irinotecan liposomal injection, combined with 5-FU/leucovorin, was recently approved by the FDA to be used as second-line treatment following gemcitabine-based therapy in patients with metastatic disease. For the 2016 update, the panel voted to include this regimen as second-line treatment for patients with good performance status following gemcitabine-based therapy in the metastatic setting as a Category 1 recommendation.

The AIO-PK0104 trial also assessed second-line therapy in a randomized crossover trial and found capecitabine to be efficacious after progression on gemcitabine/erlotinib in patients with advanced disease.³⁰⁶ In this trial, capecitabine/erlotinib followed by gemcitabine gave similar outcomes to the aforementioned sequence.

Chemoradiation Approaches

In patients with pancreatic cancer, radiation is usually given concurrently with gemcitabine- or fluoropyrimidine-based chemotherapy. Chemotherapy is used as a radiosensitizer, increasing the toxicity of radiation to tumor cells. Although the mechanism of radiosensitization is not entirely clear, it is postulated that gemcitabine and fluoropyrimidines decrease the number of tumor cells in the S phase of the cell cycle, a stage at which cells are resistant to radiation damage.³⁰⁷

Chemoradiation is sometimes used for pancreatic cancer in the resectable and adjuvant settings, because of its potential to decrease the likelihood of local recurrence. It is also sometimes used in the locally advanced setting, namely in those patients who do not progress during initial chemotherapy. Chemoradiation is also often incorporated into neoadjuvant regimens, although randomized trials demonstrating the role of chemoradiation in this setting have not been done.

Chemoradiation can also be given as second-line therapy in patients with locally advanced unresectable disease, if chemoradiation was not previously given and if the primary site is the sole site of progression. Finally, radiation without chemotherapy is used in the metastatic setting as palliation for pain refractory to narcotic therapy. Varying levels of evidence support the use of chemoradiation in each setting, as discussed in more detail below.

Adjuvant Chemoradiation

In 1985, the Gastrointestinal Tumor Study Group (GITSG) initially reported that the median survival of patients undergoing pancreatoduodenectomy could be prolonged almost 2-fold by postoperative chemoradiation.^{308,309} In this study, patients were randomly assigned to either observation or RT combined with an intermittent bolus of 5-FU after resection. A standard split course of 4,000 cGy was used. 5-FU, 500 mg/m² daily for 3 days, was given concurrently with each 2,000-cGy segment of RT. The 5-FU regimen was then continued weekly for a full 2 years. In addition to a prolonged median survival, chemoradiation also resulted in a 2-year actuarial survival of 42%, compared with 15% in the control group.³⁰⁸

Other studies have also shown an advantage to adjuvant chemoradiation over observation after resection. EORTC conducted a phase III trial (40891) in patients with both ampullary and pancreatic

adenocarcinoma assessing adjuvant radiotherapy and 5-FU versus observation alone after surgery. They found that the benefit of therapy was small in a subset of patients with pancreatic adenocarcinoma and was not statistically significant.³¹⁰ At a median follow-up of 11.7 years, no statistically significant differences were observed in the different study arms with respect to PFS or OS for the subset of patients with pancreatic cancer.³¹¹

More contemporary studies have compared different regimens incorporating chemoradiation. The Radiation Therapy Oncology Group study RTOG 9704 was a phase III study that evaluated postoperative adjuvant treatment of resected pancreatic adenocarcinoma using either gemcitabine or fluorouracil for 3 weeks before and 12 weeks after 5-FU-based chemoradiation for both groups.³¹² This trial, which utilized daily fractionated radiotherapy, included prospective quality assurance of all patients, including central review of preoperative CT imaging and radiation fields.³¹³ Results of this study showed that, for patients with tumors of the pancreas head (representing 388 of the 451 patients enrolled in the trial), there was a non-statistically significant increase in OS in the gemcitabine arm compared with the 5-FU arm (median and 3-year survival of 20.5 months and 31% vs. 16.9 months and 22%; $P = .09$); this benefit became more pronounced on multivariate analysis (HR, 0.80; 95% CI, 0.63–1.00; $P = .05$). The 5-year analysis of RTOG 9704 showed that there was in fact no difference in OS between the two groups, although patients with tumors in the head of the pancreas showed a trend toward improved OS with gemcitabine ($P = .08$) upon multivariate analysis.³¹⁴

The Role of Radiation in Adjuvant Regimens

The majority of the data comparing chemotherapy to chemoradiation in the adjuvant setting do not generally show an advantage to the addition of radiation. Results of ESPAC-1 suggested that the addition of



radiation to adjuvant 5-FU chemotherapy may be unnecessary and perhaps even harmful (OS, 13.9, 21.6, and 19.9 months for chemoradiation, chemotherapy, and chemotherapy plus chemoradiation, respectively),²⁷⁸ although the ESPAC-1 trial has been criticized for lack of attention to quality control for RT.³¹⁵⁻³¹⁷ A phase II study by GERCOR randomized patients to adjuvant gemcitabine or adjuvant gemcitabine-based chemoradiation.³¹⁸ No differences were seen in OS (24.4 months vs. 24.3 months) or DFS (10.9 months vs. 11.8 months) between the groups, but with only 45 patients in each arm no *P* values were reported. In addition, the multicenter, open-label, randomized phase III CapRI trial found that adjuvant chemoradiation with 5-FU, cisplatin, and interferon alfa-2b (IFN α -2b) followed by 5-FU chemotherapy gave outcomes no better than adjuvant treatment with 5-FU alone.³¹⁹

A 2012 meta-analysis of 15 prospective, randomized trials found that adjuvant chemoradiation did not improve DFS, 2-year survival, or OS (OR, 0.99; *P* = .93) compared to surgery alone, while adjuvant chemotherapy improved all 3 outcomes (odds ratio for OS, 1.98; *P* < .001).³²⁰ A 2013 meta-analysis of 9 trials found similar results, with HRs for death compared to no adjuvant treatment of 0.62 for 5-FU (95% CI, 0.42–0.88), 0.68 for gemcitabine (95% CI, 0.44–1.07), 0.91 for chemoradiation (95% CI, 0.55–1.46), 0.54 for chemoradiation plus 5-FU (95% CI, 0.15–1.80), and 0.44 for chemoradiation plus gemcitabine (95% CI, 0.10–1.81).³²¹

However, a population-based assessment of outcomes of patients in the NCDB with pancreatic cancer resected from 1998 to 2002 found the opposite result: chemoradiation gave better OS than chemotherapy in a performance-status–matched comparison to no adjuvant treatment (HR, 0.70; 95% CI, 0.61–0.80 vs. HR, 1.04; 95% CI, 0.93–1.18).³²² A multi-institutional pooled analysis of 955 consecutive patients who had R0-1

resections for pancreatic cancer also supports the supposition that adjuvant chemoradiation improved survival compared to chemotherapy alone (OS, 39.9 months vs. 27.8 months; *P* < .001).³²³

To definitively clarify the role of chemoradiation following gemcitabine monotherapy in the adjuvant setting, RTOG is conducting trial 0848 (ClinicalTrials.gov NCT01013649). Patients without evidence of progressive disease after 5 cycles of gemcitabine-based chemotherapy are being randomized to 1 additional round of chemotherapy or 1 additional round of chemotherapy followed by chemoradiation with capecitabine or 5-FU. The primary endpoint is OS, and the trial is estimated to be completed in 2020.

Benefit of Adjuvant Chemoradiation in Patient Subsets

It has been suggested that subsets of patients (eg, patients with R1 resections or positive lymph nodes) may be more likely to benefit from adjuvant chemoradiation.

Studies that have looked at R0 or R1 subsets of patients have found mixed results. For instance, patients treated in the ESPAC-1 trial did not derive a benefit from the addition of radiation to adjuvant chemotherapy, irrespective of margin status.³²⁴ In contrast, results from a prospectively collected database of 616 patients with resected pancreatic cancer at the Johns Hopkins Hospital found that adjuvant chemoradiation benefited both the R0 and R1 subsets compared to observation alone.³²⁵ The Mayo Clinic performed a retrospective review of 466 patients who had R0 resections for pancreatic adenocarcinoma, and found an OS benefit of adjuvant chemoradiation over observation.³²⁶ In addition, a retrospective review of greater than 1200 resected patients from the Johns Hopkins Hospital and the Mayo Clinic who received adjuvant 5-FU–based chemoradiation or were observed following resection found that chemoradiation improved outcomes regardless of

margin status (R0: RR, 0.61; 95% CI, 0.47–0.77, $P < .001$; R1: RR, 0.52; 95% CI, 0.36–0.74; $P < .001$).³²⁷ A meta-analysis of 4 RCTs found evidence for an increased survival benefit of adjuvant chemoradiation in the R1 subset (HR for death, 0.72; 95% CI, 0.47–1.10) over the R0 subset (HR for death, 1.19; 95% CI, 0.95–1.49).³²⁸

Fewer analyses have looked at the role of chemoradiation in resected patients with positive lymph nodes. One retrospective review compared outcomes of 94 patients who underwent distal pancreatectomy at the Johns Hopkins Hospital and either received adjuvant chemoradiation or were just observed following resection.³²⁹ An exploratory subset analysis suggested that patients with positive lymph nodes derived greater benefit from adjuvant chemoradiation than those with negative nodes. In addition, a meta-analysis of 4 randomized controlled adjuvant trials found that chemoradiation had a similar lack of benefit in patients with positive and negative lymph nodes.³³⁰

Chemoradiation for Locally Advanced Disease

Chemoradiation is a conventional option for the management of unresectable locoregional pancreatic cancer, although the utility of chemoradiation in this population of patients is controversial.³³¹ It is mainly used in selected patients who do not develop metastatic disease during initial chemotherapy.

A recent meta-analysis identified 15 RCTs (1128 patients) that compared chemoradiation to either chemotherapy or radiation in the locally advanced setting.³³² Whereas combined modality therapy significantly improved survival compared to radiation alone, survival was the same when compared to those receiving chemotherapy alone. Increased toxicity was observed in the chemoradiation group.

The role of chemoradiation in locoregional pancreatic cancer was initially defined in a trial conducted in locally advanced disease by GITSG.³⁰⁹ In this study, the combination of bolus 5-FU and split-course radiation (total dose, 4000 cGy) was compared with radiation alone or with 6000 cGy combined with 5-FU. A nearly 2-fold increase in median survival (42.2 vs. 22.9 weeks) was observed with the regimen of bolus 5-FU and 4000 cGy compared with radiation alone. Subsequent generations of studies have sought to optimize the use of 5-FU, and most contemporary studies no longer use split-course radiation.³³³ Gemcitabine has also been used as a radiation sensitizer in the locally advanced setting.³³⁴⁻³³⁸ Evidence suggests that concurrent gemcitabine and radiation can yield similar or better outcomes when compared with 5-FU–based chemoradiation in the setting of locally advanced disease.^{333,337,339,340} The use of capecitabine as a radiosensitizer has also been assessed in this setting and appears to be effective.³⁴¹

Upfront Chemoradiation in Locally Advanced Disease

Results of 2 early randomized trials comparing upfront chemoradiation to chemotherapy in locally advanced disease were contradictory.^{342,343} Three phase II trials also assessed the upfront chemoradiation approach in locally advanced pancreatic adenocarcinoma, with median survival rates ranging from 8.2 to 9 months.^{334,344-346} Results from small, single-arm trials of upfront chemotherapy followed by chemoradiation in locally advanced disease have been discussed.³⁴⁷

The phase III randomized ECOG-4201 trial, which assessed gemcitabine compared with gemcitabine plus RT followed by gemcitabine alone in patients with locally advanced, unresectable pancreatic cancer, was closed early due to poor accrual. However, an ITT analysis of data for the 74 patients enrolled in this study showed that median OS was significantly longer in the chemoradiation therapy arm of the study (11.1 months vs. 9.2 months; $P = .017$).³⁴⁸ However,

the poor accrual rate decreased its statistical power, there was no difference in PFS, and the confidence intervals for OS overlapped between the two groups of patients, leading some to state that the results do not rise to the level of evidence required to determine standard of care.³⁴⁹

The benefit of chemotherapy versus chemoradiation was also addressed in the phase III FFCD-SFRO study from France, in which patients with locally advanced pancreatic cancer were randomly assigned to receive either gemcitabine alone or an intensive induction regimen of chemoradiation with 5-FU plus cisplatin followed by gemcitabine maintenance treatment.³⁵⁰ In this study, gemcitabine alone was associated with a significantly increased OS rate at 1 year compared with chemoradiation (53% vs. 32%; HR, 0.54; 95% CI, 0.31–0.96; $P = .006$). This study was stopped before the planned accrual, because an interim analysis revealed that patients in the chemoradiation arm had a lower survival rate. Also, patients in the chemoradiation arm experienced severe toxicity and were more likely to receive a shorter course of maintenance therapy with gemcitabine, suggesting that the observed differences in survival were most likely attributable to the extreme toxicity of this particular chemoradiation regimen.

Thus, the role of upfront chemoradiation in the setting of locally advanced pancreatic cancer is still undefined. If patients present with poorly controlled pain or local invasion with bleeding, then starting with upfront chemoradiation therapy is an option.^{334,336}

Chemoradiation Following Chemotherapy in Locally Advanced Disease

Starting with 2 to 6 cycles of systemic chemotherapy followed by chemoradiation therapy is an option for selected patients with unresectable disease and good performance status who have not

developed metastatic disease.³⁵¹⁻³⁵³ This sequence is especially recommended in cases where: 1) it is highly unlikely that the patient will become resectable (ie, complete encasement of superior mesenteric/cealic arteries); 2) there are suspicious metastases; or 3) the patient may not be able to tolerate chemoradiation. Employing an initial course of chemotherapy may improve systemic disease control in these cases. In addition, the natural history of the disease can become apparent during the initial chemotherapy, thus allowing the selection of patients most likely to benefit from subsequent chemoradiation. For example, a retrospective analysis of outcomes from the GERCOR studies indicated that first-line treatment with chemotherapy may be a useful strategy for selecting patients with locally advanced disease who are more likely to benefit from subsequent chemoradiation therapy.³⁵¹

In the international phase III LAP07 RCT, patients with locally advanced pancreatic cancer ($n = 269$) received chemoradiation with capecitabine following four months of induction chemotherapy with either gemcitabine monotherapy or gemcitabine and erlotinib.³⁵⁴ Chemoradiation in this setting provided no survival benefit, compared to chemotherapy only (HR, 1.03; 95% CI, 0.79–1.34; $P = .83$). Differences were noted in other potentially meaningful outcomes such as time to reinitiation of therapy (159 days in the chemoradiation arm vs. 96 days in the control arm; $P = .05$) and local tumor progression (34% in the chemoradiation arm vs. 65% in the chemotherapy only arm; $P < .0001$).³⁵⁵

In a more recent single-arm phase II trial examining stereotactic body radiotherapy (SBRT) following gemcitabine monotherapy in 49 patients with locally advanced pancreatic cancer, this regimen demonstrated relatively low toxicity and favorable freedom from local disease progression.³⁵⁶ Because there are now more active chemotherapy



regimens than gemcitabine monotherapy, additional studies are planned to assess the role of radiation after more active chemotherapy.

Advanced Radiation Techniques

Intensity-modulated radiation therapy (IMRT) is increasingly being applied for therapy of locally advanced pancreatic adenocarcinoma and in the adjuvant setting with the aim of increasing radiation dose to the gross tumor while minimizing toxicity to surrounding tissues.³⁵⁷⁻³⁶¹ A retrospective treatment planning study evaluated the dose escalation that might have been possible in 15 patients with locally advanced, unresectable pancreatic adenocarcinoma if IMRT had been used instead of 3-D conformal planning.³⁶¹ While the authors concluded that the IMRT plans would allow for significant increase in target volume dose with substantial dose reductions to local organs at risk, there is no clear consensus on the appropriate maximum dose of radiation when IMRT is used. A recent systematic review including 13 IMRT studies showed that IMRT does not improve survival outcomes, compared to 3D-CRT.³⁶² However, toxicities grade 3 or greater were more numerous in 3D-CRT, relative to IMRT ($P = .017$). These toxicities were mainly gastrointestinal, specifically nausea/vomiting and diarrhea. IMRT resulted in reduced grade 3/4 toxicities when the authors made a cross-study comparison of toxicities in patients who received a similar 5-FU–based regimen with 3-D conformal radiation in the RTOG 9704 trial.^{312,363} Comparing the 2 trials, rates of grade 3/4 nausea and vomiting were 0% vs. 11% ($P = .024$), and rates of grade 3/4 diarrhea were 3% vs. 18% ($P = .017$),³⁶³ suggesting that IMRT may be well tolerated and allow for higher radiation doses to the tumor.³⁶³ There is no clear consensus on the appropriate maximum dose of radiation when IMRT technique is used.

SBRT is another technique aimed at increasing dose to the gross tumor while sparing radiation to nearby healthy tissue.³⁶⁴⁻³⁶⁹ Retrospective analysis of 77 patients with unresectable disease demonstrated that while SBRT gave effective local control, it gave no improvement to OS and was associated with significant toxicities.³⁶⁴ However, another retrospective review of 71 patients reported a median OS of 10.3 months with only 3 patients (4%) experiencing grade 3 toxicity.³⁶⁷ No standard total dose or dose per fraction has been established for SBRT, and the panel currently recommends that SBRT only be utilized as part of a clinical trial.

Intraoperative radiation therapy (IORT) can allow for higher doses of radiation because sensitive structures can be excluded from the radiation fields. IORT is sometimes administered to patients with borderline resectable disease who have received maximal neoadjuvant therapy to sterilize close or involved margins at the time of surgery, although data in this setting are lacking. It is also sometimes used when a patient is found to be unresectable at the time of surgery and in cases of locally recurrent disease. Most studies of IORT in patients with locally advanced pancreatic cancer found that while local control may be improved, no change in survival is evident with use of IORT because of the high frequency at which metastatic disease develops.³⁷⁰⁻³⁷³ Some groups, however, believe that IORT can offer benefits in very carefully selected patients with non-metastatic disease.³⁷⁴⁻³⁷⁶ Overall, there is no clear established role for IORT in patients with pancreatic cancer,³⁷⁷ and the panel believes it should only be performed at specialized centers.

Management of Metastatic Disease

The primary goals of treatment for metastatic pancreatic cancer are palliation and lengthened survival. Survival benefits are usually limited to patients with adequate performance status (ECOG 0-1, with good

pain management, patent biliary stent, and adequate nutritional intake). Systemic therapy is therefore recommended for patients with metastatic disease and good performance status, as described in *Systemic Therapy Approaches*, above, and in the guidelines.

Patients who present with poor performance status may benefit from the administration of gemcitabine (category 1 recommendation), but comfort-directed measures are always paramount (see *Palliative and Supportive Care*, below, and the NCCN Guidelines for Supportive Care, available at www.NCCN.org). An alternative option for these patients is palliative and best supportive care.

Before initiating cytotoxic therapy, an open dialogue regarding the goals and side effects of treatment should take place and, if needed, adjunctive strategies can be used (see *Palliative and Supportive Care*, below). Of note, patients with advanced disease may have abrupt changes in clinical status. Therefore, if treatment is begun, it should proceed with close follow-up. Patients may experience sudden onset of bleeding or thromboembolism, rapidly escalating pain, biliary stent occlusion, cholangitis, or other infections. Moreover, clinically meaningful tumor progression may develop quickly, and tumor-related symptoms may be inappropriately attributed to chemotherapy or other causes. For instance, patients who complain of intractable nausea and vomiting may have gastric outlet obstruction rather than chemotherapy-induced emesis. Peritoneal carcinomatosis may manifest as ascites or in its more subtle form, as abdominal bloating, as decreased oral intake, and as constipation.

For patients who do well on initial therapy, a chemotherapy holiday is appropriate, or maintenance therapy can be considered (see *Possible Role of Maintenance Therapy in Advanced Disease*, above). After progression, second-line therapy is possible, especially in patients who

maintain a good performance status (see *Second-Line Systemic Therapy in the Advanced Setting*, above). Prior to commencing second-line therapy, serial 3D CT or MRI imaging of known sites of disease to determine therapeutic benefit is recommended by the panel. However, patients may demonstrate progressive disease clinically without objective evidence of progression (also for *Management of Locally Advanced Disease*; see below).

Management of Locally Advanced Disease

As in the metastatic setting, the primary goals of treatment of patients with unresectable, locoregional pancreatic cancer are palliation and lengthened survival. Also, as in metastatic disease, patients with locally advanced disease are treated with systemic therapy based on their performance status. Gemcitabine (category 1) and palliative and best supportive care are options for patients with poor performance status, whereas patients with good performance status can be treated with more intensive therapy (eg, FOLFIRINOX [category 2A], gemcitabine/albumin-bound paclitaxel [category 2A]) or with gemcitabine monotherapy (category 2A), as described in *Systemic Therapy Approaches*, above, and in the guidelines.

Historically, most studies in the locally advanced setting used gemcitabine monotherapy. However, there is an increasing emphasis on understanding the role of modern, more active regimens in locoregional unresectable disease. The experience with FOLFIRINOX in 22 patients with locally advanced pancreatic cancer at the Massachusetts General Hospital Cancer Center through February 2012 was recently reported.³⁷⁸ An overall response rate of 27% was observed, and the median PFS was 11.7 months. Five patients (23%) were able to undergo R0 resections, although 3 of these patients experienced distant recurrence by 5 months. It was also reported that



32% of patients receiving FOLFIRINOX required greater than or equal to 1 hospitalization or visit to the emergency department during treatment.

Other studies and case reports addressing the use of chemotherapy with or without chemoradiation in patients with locally unresectable disease have noted that the opportunity for curative intent resection occasionally arises.³⁷⁸⁻³⁸⁷ The panel believes that patients with a significant response to chemotherapy and/or chemoradiation may be considered for surgical resection, but acknowledges that such conversions are rare in patients with true locally advanced disease. Following resection, these patients have similar survival rates as those initially determined to be resectable.³⁸⁸

The use of chemoradiation following chemotherapy in locally advanced disease is discussed above (See *Chemoradiation for Locally Advanced Disease*).

Management of Resectable and Borderline Resectable Disease

Surgical Management

Surgical resection is the only potentially curative technique for managing pancreatic cancer. However, more than 80% of patients present with disease that cannot be cured with surgical resection.³⁸⁹ Early concerns about high mortality associated with various pancreatic resection procedures³⁹⁰ have now been lessened by studies demonstrating an acceptably low (<5%) mortality in experienced centers (see *Effect of Clinical Volume*, below).³⁹¹ Even under the most optimal clinical trial conditions, however, the median survival of resected patients following adjuvant therapy ranges from 20.1 to 23.6 months.^{210,278,279,312} Negative margin status (ie, R0 resection), tumor DNA content, tumor size, and absence of lymph node metastases are the

strongest prognostic indicators for long-term patient survival.³⁹²⁻³⁹⁴ With respect to margin status, there is evidence for the converse statement—the survival benefits of an R1 resection may be comparable to definitive chemoradiation without surgery.³⁹⁵⁻³⁹⁷

Criteria for Resection

The NCCN Panel recommends that decisions about diagnostic management and resectability always involve multidisciplinary consultation at high-volume centers with use of appropriate high-quality imaging studies to evaluate the extent of disease. Although it is clear that patients with visceral, peritoneal, or pleural metastases or with metastases to nodes beyond the field of resection derive no benefit from resection, institutions differ in their approaches to patients with locoregional disease involvement (pancreas and peripancreatic lymph nodes).

Based on their clinical experience with the primary management of pancreatic tumors, an expert consensus group developed criteria to define tumor resectability so as to improve patient selection for surgery and increase the likelihood of an R0 resection.^{126,398} Other groups have also put forth definitions of resectability of pancreatic cancer.³⁹⁹⁻⁴⁰¹ A more restrictive definition of borderline resectable pancreatic tumors has also been described.⁴⁰² This definition uses degrees of contact (eg, interface between tumor and SMA measuring <180° of vessel wall circumference) rather than subjective terms such as abutment and impingement. The panel endorses this definition for use in clinical trials. Using any of these sets of criteria, tumors are classified as resectable; borderline resectable; or unresectable (ie, locally advanced or metastatic disease).

The panel has adapted the criteria put forth by other groups and lists its recommended criteria for defining resectability status in the guidelines.



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Pancreatic Adenocarcinoma

The consensus of the panel is that patients should be selected for surgery on the basis of curative intent as determined by the probability of obtaining negative (R0) resection margins. Overall, the likelihood of attaining negative margins is the key criterion for consideration when determining whether a patient is a potential candidate for resection.^{401,403} In this context, a borderline resectable lesion can be defined as one in which there is a higher likelihood of an incomplete resection. Patients at high risk for positive surgical margins are not considered to be good candidates for an upfront resection. Furthermore, the panel recommends that patient factors be considered when deciding whether a patient is a surgical candidate. Age of the patient, comorbidities, performance status, and frailty are all things to be discussed during the multidisciplinary review. Please refer to the NCCN Guidelines for Older Adult Oncology (available at www.NCCN.org) for further discussion of the treatment of older patients.

Primary Surgery for Pancreatic Cancer

The nature and extent of the surgery for resectable tumors depend on the location and size of the tumor. Because tumors of the pancreatic body and tail cause symptoms late in their development, they are usually advanced at diagnosis and are rarely resectable. When tumors in the pancreatic tail are resectable, distal pancreatectomy, in which the surgeon removes the tail and body of the pancreas, as well as the spleen, is commonly performed. If the cancer diffusely involves the pancreas or is present at multiple sites within the pancreas, a total pancreatectomy may be required, where the surgeon removes the entire pancreas, part of the small intestine, a portion of the stomach, the common bile duct, the gallbladder, the spleen, and nearby lymph nodes. Patients with tumors in the head of the pancreas, who usually present because of jaundice, are treated with open or laparoscopic pancreatoduodenectomy (ie, the Whipple procedure).^{404,405}

If the tumor is found to be unresectable during surgery, the panel recommends biopsy confirmation of adenocarcinoma at this time, if a biopsy was not performed previously. If a patient with jaundice is found to be unresectable at surgery, then the panel recommends surgical biliary bypass at that time. If a stent has been previously placed, then surgical biliary bypass could be considered. In addition, gastrojejunostomy can be considered if appropriate regardless of jaundice (category 2B for prophylactic gastrojejunostomy). Celiac plexus neurolysis can also be performed, especially when indicated by pain in a patient with jaundice (category 2B if no pain). See *Severe Tumor-Associated Abdominal Pain*, below, for more details about these procedures.

In patients with suspected borderline resectable disease for whom cancer is not confirmed following repeated biopsy with EUS-FNA (preferred), intraoperative biopsy is recommended. If resectable disease is found in these patients, then surgical resection followed by adjuvant therapy is recommended. If unresectable disease is found, then recommendations for management of locally advanced or metastatic disease should be followed (see above). If these patients present with jaundice, surgical biliary bypass and gastrojejunostomy (category 2B for prophylactic gastrojejunostomy) should be considered, as well as celiac plexus neurolysis for pain (category 2B if no pain).

Pancreatoduodenectomy (Whipple Procedure)

Achievement of a margin-negative dissection must focus on meticulous perivascular dissection of the lesion in resectional procedures, recognition of the need for vascular resection and/or reconstruction, and the potential need for extra-pancreatic organ resection. Of course, the biology of the cancer might not allow for an R0 resection even with the most meticulous surgery.

Medial dissection of pancreatic head lesions is best achieved by complete mobilization of the PV and SMV from the uncinate process (assuming no evidence of tumor infiltration). Further, skeletonization of the lateral, posterior, and anterior borders of the SMA down to the level of the adventitia will maximize uncinate yield and radial margin (see Figure 1).^{406,407} Optimal dissection and skeletonization of the SMA can be achieved using ultrasonic or thermal dissectors (Harmonic scalpel or LigaSure). Division of the retroperitoneal tissues between the uncinate process and the SMA with a stapler or a clamp and cut technique may leave up to 43% of the soft tissue between the uncinate process and the SMA in situ and result in suboptimal clearance and increase the risk of an R1 resection.^{408,409}

Analysis of the pancreatic neck and bile duct at time of surgery by frozen section may be considered. A retrospective analysis of 1,399 patients who underwent pancreaticoduodenectomy showed that additional resection to achieve a negative surgical margin following analysis of a positive frozen section of the pancreatic neck is not associated with improved survival.⁴¹⁰ Frozen sections should be taken approximately 5 mm from the transection margin, with the clean-cut side facing up, to avoid cautery artifact that may confound analysis and result in false negatives. If tumor is located within 5 mm of margins, further excision of the pancreas should be considered to ensure at least 5 mm of clearance.

In the absence of frank venous occlusion noted on preoperative imaging, the need for lateral venorrhaphy or complete PV or SMV resection and reconstruction to achieve an R0 resection may be suggested, but it is often not known until division of the pancreatic neck has occurred. Tethering of the carcinoma to the lateral wall of the PV is not uncommon and requires careful dissection to free the vein from the pancreatic head if it is possible to do so. Differentiation of tumor

infiltration into the vein wall from tumor-related desmoplasia is frequently impossible to ascertain. The liberal use of partial or complete vein resection when vein infiltration is suspected during Whipple procedures has been studied.⁴¹¹⁻⁴¹³ On evaluation of excised vein specimens, only 60% to 70% had histologic evidence of frank tumor involvement, and R0 resections were still not obtainable in 10% to 30% of patients despite increasing the magnitude of the operative procedure. However, if an R0 resection is obtained with vein excision, longevity appears similar to those with R0 resections without venous involvement, with no significant increase in morbidity and mortality. These data support an aggressive approach to partial or complete vein excision if tumor infiltration is suspected, although acceptance of this concept (particularly with respect to vein resection) is not universal.

Although numbers are more limited, similar findings have been noted with respect to hepatic arterial resection and reconstruction.^{413,414} Others, however, have noted poor short- and long-term outcomes with arterial resection.^{415,416} While further data with respect to arterial resection are clearly needed, judicious utilization of this technique would appear to be reasonable in very select populations.

A population-based study of 10,206 patients from the Nationwide Inpatient Sample from years 2000 through 2009 found that vascular reconstruction (about 90% venous and 10% arterial) is associated with a higher risk of intraoperative and postoperative complications.⁴¹⁶ No difference in mortality was seen.

Distal Pancreatectomy

The goals of left-sided resection are similar to those of pancreaticoduodenectomy, although they are often more difficult to achieve because of the advanced stage at which most of these cancers are discovered. Spleen preservation is not indicated in distal



pancreatectomy for adenocarcinoma, and an R0 distal pancreatectomy for adenocarcinoma mandates en bloc organ removal beyond that of the spleen alone in up to 40% of patients.^{417,418} In addition, similar to the Whipple procedure, lateral venorrhaphy, vein excision and reconstruction, and dissection to the level of the celiac axis and SMA adventitia should be performed if complete tumor clearance can be achieved.^{418,419} Utilization of these radical resections is associated with an increase in blood loss, transfusion requirements, operating time, length of stay, and morbidity, but mortality remains rare.⁴¹⁷⁻⁴¹⁹ Encouragingly, tumor clearance (R0 resection) has been reported in up to 72% to 91% of patients, with long-term survival equivalent to those having standard resection for more localized disease.^{418,419} Local recurrence, however, remains problematic even with pathologically negative margins.⁴¹⁹

There is an increasing role for laparoscopic distal pancreatectomy. A meta-analysis including 29 observational studies with 3,701 patients showed that laparoscopic distal pancreatectomy may decrease intraoperative blood loss ($P < .01$), time to first oral intake ($P < .01$), and length of hospital stay ($P < .01$), as compared to open distal pancreatectomy.⁴²⁰ Results from 172 patients treated at the Mayo Clinic found significant benefits in the patients who had laparoscopic versus open resections in blood loss, the need for blood transfusions, and the length of hospital and intensive care unit stays without any difference in oncologic outcomes.⁴²¹ In addition, results from a meta-analysis of 4 studies of 665 total patients suggest that the laparoscopic method is safe and results in shorter hospital stays.⁴²² Furthermore, results from a population-based, retrospective cohort study that included 8957 patients showed similarly that the laparoscopic approach can decrease complication rates and shorten hospital stays.⁴²³

Portal Vein Resection

Vascular invasion has been a conventional contraindication to pancreatic resection. Early attempts at resection and reconstruction of the SMA and SMV in the 1970s were associated with poor results in a few patients who underwent “regional” pancreatectomy.⁴²⁴ Both autologous and synthetic grafts were used for arterial and venous reconstructions. As morbidity from pancreatoduodenectomy decreased, a subset was identified of patients who were in need of resection of the SMV wall to achieve negative margins during removal of their tumors. Thus, in the 1990s, there was renewed interest in vein resection for complete resections. The group from the University of Texas MD Anderson Cancer Center has championed this approach, demonstrating that vein resection and reconstruction can allow for complete resection and is not associated with increased morbidity or mortality when compared with patients who did not require vein resection.⁴²⁵ Furthermore, long-term outcome is not significantly worse for patients undergoing venous resection during pancreatoduodenectomy compared to patients who receive standard pancreatoduodenectomy.⁴²⁶

Although compelling, this approach has not been universally accepted. During the 1990s, several studies reported operative mortality of 0% to 16.5%, 3-year Kaplan-Meier survival of 12% to 23%, and median survival of 5 to 14 months in patients receiving vein resection.⁴²⁷⁻⁴³⁰ One study found that properly selected patients with adenocarcinoma of the pancreatic head who required vein resection ($n = 141$) had a median survival of approximately 2 years that did not differ from those having standard pancreatoduodenectomy and was superior to historical patients believed to have locally advanced disease who did not receive surgical treatment.⁴¹³ A meta-analysis of 22 retrospective studies (2890 patients) found that vein resection resulted in perioperative morbidity and mortality equal to that of standard resection, but R0 resection rates



were lower in that group.⁴³¹ In a recent multi-institutional database analysis of 492 patients undergoing pancreaticoduodenectomy, R0 resection rates were no different between the 14% who had vein resection compared to those without venous involvement (66% vs. 75%; $P = NS$).⁴³² Nevertheless, a few groups have recommended caution and only use vein resection for selected patients.

Pylorus Preservation

Reconstruction options for the stomach after pancreatoduodenectomy center on preservation of the pylorus. Traverso and Longmire⁴³³ reported the modern use of pylorus preservation in 1978. The hypothesis was that preservation would improve emptying and provide nutritional benefit, but the benefits have been inconsistent to date. Yeo et al reported no adverse effects of pylorus preservation⁴³⁴; however, van Berge Henegouwen et al reported longer nasogastric drainage times.⁴³⁵ In several randomized and nonrandomized studies,⁴³⁶⁻⁴⁴¹ the pylorus-preserving procedure seemed to be associated with shorter surgical duration. No consistent data suggest that pylorus preservation leads to a better quality of life or nutritional status in patients after resection. Thus, pylorus-preserving pancreatoduodenectomy remains an unproven but certainly acceptable alternative to classic pancreatoduodenectomy performed with antrectomy.

Pancreatic Anastomosis

Efforts have focused on preventing pancreatic leaks and fistulas, which are morbid and potentially lethal complications of pancreatoduodenectomy. Pancreaticojejunostomy has traditionally been the standard reconstruction and is the major focus of morbidity and mortality after pancreatoduodenectomy because of leaks, abscess formation, and fistulas from this anastomosis. A randomized study at Johns Hopkins Hospital found no difference in fistula rates after pancreaticojejunostomy and pancreaticogastrostomy.⁴⁴² However, a

more recent multicenter, randomized, superiority trial compared the outcomes of 329 patients undergoing pancreaticoduodenectomy with either pancreaticojejunostomy or pancreaticogastrostomy.⁴⁴³ A significant difference was seen in the primary outcome measure of postoperative fistulas, which occurred in 19.8% of patients in the pancreaticojejunostomy group and 8.0% of patients in the pancreaticogastrostomy group (OR, 2.86; 95% CI, 1.38–6.17; $P = .002$). An increase in grade ≥ 3 a postoperative complications was seen, however, in the pancreaticogastrostomy group (24% vs. 21%). Criticisms of this trial have been published.⁴⁴⁴ Although a meta-analysis of 4 RCTs (676 patients) concluded that pancreaticogastrostomy is associated with a lower risk of fistula formation than pancreaticojejunostomy (RR, 0.41; 95% CI, 0.21–0.62),⁴⁴⁵ the optimal approach to anastomosis remains undefined.⁴⁴⁶

Surgeons have also examined various other options for the pancreaticojejunal anastomosis; end-to-end, end-to-side, duct-to-mucosa, and invaginating techniques have all proven to be safe and effective.^{447,448} Results of a prospective trial show that pancreatic fistula can be almost entirely avoided by a technique that combines placement/tying of sutures under magnification with meticulous attention to blood supply.⁴⁴⁹ Stents used in the 1930s and 1940s continue to be used today, but data suggest that they do not decrease leak rates.⁴⁵⁰

In addition to technical modifications, octreotide has been examined for its ability to decrease postoperative pancreaticojejunal leaks in patients undergoing pancreatic resections. However, octreotide did not decrease fistula rates when assessed in 2 prospective, randomized, double-blind, placebo-controlled studies (at the University of Texas MD Anderson Cancer Center and Johns Hopkins Hospital).^{451,452} Pasireotide, in contrast, significantly decreased the rate of grade ≥ 3 fistula, leak, or abscess in a single-center, double-blind, RCT of 300 patients (9% in

pasireotide group vs. 21% in placebo group; RR, 0.44; 95% CI, 0.24–0.78; $P = .006$).⁴⁵³ Finally, the use of fibrin glue sealant does not appear to decrease the rate of pancreatic fistulas.⁴⁵⁴

Extended Lymphadenectomy

The role of lymph node dissection as a component of pancreatoduodenectomy has been explored. In the 1970s and 1980s, pathology and autopsy studies demonstrated a high incidence of nodal metastasis (sometimes as high as 80%), leading some groups to propose a more aggressive lymphadenectomy in an attempt to regionally control disease.^{455,456} A standard lymphadenectomy in patients undergoing pancreatoduodenectomy entails removal of nodes at the duodenum and pancreas and on the right side of the hepatoduodenal ligament, the right side of the SMA, and the anterior and posterior pancreatoduodenal lymph nodes.⁴⁵⁷ An extended lymphadenectomy is most commonly performed in the United States by removing not only the nodes removed in the standard procedure, but also the soft tissue in the retroperitoneum from the hilum of the right kidney to the left lateral border of the aorta on the right side, and from the PV to the origin of the inferior mesenteric artery on the left.⁴⁵⁸

Several prospective, randomized trials have addressed the role of lymphadenectomy in patients undergoing pancreatoduodenectomy. The Italian Multicenter Lymphadenectomy Group reported on a series of 81 patients randomly assigned to pancreatoduodenectomy with or without extended lymph node resection. Although the statistical power was low, this study did not support the concept that an extended lymphadenectomy was a good prognostic factor.⁴⁵⁹ A larger randomized prospective trial was performed at Johns Hopkins Hospital from 1996 through 2001 to evaluate the role of extended lymph node dissections.⁴⁶⁰ The group of patients who received the regional lymphadenectomy in addition to pancreatoduodenectomy had longer

operation times, but overall median survival did not differ between the 2 groups at 1, 3, and 5 years.^{460–462} A randomized multicenter trial in Japan came to similar conclusions.⁴⁶³ Furthermore, multiple systematic literature reviews and meta-analyses of RCTs comparing pancreatoduodenectomy with standard versus extended lymphadenectomy support the conclusion that the extended procedure does not have any impact on survival.^{464–466} In addition, patients undergoing extended lymphadenectomy have increased rates of postoperative diarrhea compared to patients undergoing the standard resection.⁴⁶⁷

The information to date thus does not show any survival advantage to performing a regional lymphadenectomy in addition to the standard pancreatoduodenectomy.⁴⁶⁸ At this point in time, data suggest that nodal metastases are a marker of systemic disease and that their removal is unlikely to alter OS. One exception might be in the situation of an otherwise R0 resection with clinically positive adenopathy outside the standard field of dissection. Overall, outside of a clinical trial, a regional lymphadenectomy should not be considered as a routine part of the Whipple procedure, although consideration can be given to sampling of the aortocaval and common hepatic artery nodes, as those with positive nodes in these positions have inferior prognoses.^{469,470}

Preoperative Biliary Drainage

The main goals of preoperative biliary drainage are to alleviate the symptoms of pruritus and cholangitis and to potentially make surgery less morbid by improving liver function preoperatively. Although controversial, several studies have suggested that pancreatoduodenectomy is associated with higher perioperative mortality when done in the setting of hyperbilirubinemia.^{471–473} Stenting of the biliary system can improve symptoms and liver function, but it is not clear whether these changes can decrease the mortality rate of the

Whipple procedure. Several prospective and retrospective studies have failed to show decreased mortality in patients with preoperative biliary drainage.⁴⁷⁴⁻⁴⁸⁰ A retrospective analysis from a prospective database of 593 patients treated with pancreatoduodenectomy at MD Anderson Cancer Center found that self-expandable metal stents did not affect postoperative complications, 30-day mortality, length of stay, anastomotic leak, margin status, or determination of unresectability during resection, although more wound infections and longer operative times were observed in this group.⁴⁸¹ In contrast, a multicenter, randomized trial comparing preoperative biliary drainage with surgery alone for 202 patients with cancer of the pancreatic head characterized by obstructive jaundice showed a nearly 2-fold increase in the rate of serious complications in the stented group (74% vs. 39%; relative risk in the surgery alone group, 0.54; 95% CI, 0.41–0.71; $P < .001$). However, no significant differences in surgery-related complications, length of hospital stay, or mortality were observed.⁴⁸²

Based on these reports, most groups who perform resection without neoadjuvant treatment advocate selective use of decompression only in patients who are symptomatic, septic, coagulopathic, have renal insufficiency, or in whom surgical resection is significantly delayed. The panel includes in this group patients who present with jaundice and potentially resectable disease if symptoms of cholangitis or fever are present or if they have significant pruritus and an expected delay to surgery of >1 week.

For patients with jaundice undergoing neoadjuvant induction therapy before pancreatic resection, biliary decompression is necessary before initiation of therapy and appears to be well tolerated with minimal increase in perioperative morbidity. The University of Texas MD Anderson Cancer Center reported on its experience with more than 300 patients, 57% of whom had preoperative biliary drainage as part of a

neoadjuvant chemoradiation program.⁴⁸³ It was found that wound complications were significantly increased in the drainage group; however, no other association was found for sepsis, fistulae, or death. Placement of a stent is thus required prior to administration of neoadjuvant therapy for patients with jaundice.⁴⁸⁴⁻⁴⁸⁷

The panel notes that stents are an evolving technology. The choice of stents includes plastic and metal; fully covered, partially covered, or uncovered; rigid; or self-expanding (also see the discussion on stents in *Palliative and Supportive Care*, below). While any stent can become occluded, several groups have reported better patency with metal stents.⁴⁸⁵⁻⁴⁸⁷ Metal stents are generally viewed as more permanent than plastic stents. Covered metal stents may give more durable patency, since the cover prevents tumor ingrowth,⁴⁸⁸ but the reported differences between covered and uncovered stents are not dramatic.^{488,489}

Furthermore, migration is more of an issue with covered stents.⁴⁸⁹ This issue has led to the introduction of partially covered stents,⁴⁹⁰ though these stents may still migrate in a substantial number of patients.^{491,492}

Most metal stents used today are self-expanding. Their small initial diameters make them easy to place, and their placement rarely requires dilation.⁴⁹⁰ Several panel members reported that their institutions use plastic stents in patients with short life expectancies (<3 months).⁴⁹⁰ A clinical trial is currently recruiting patients to compare metal and plastic stents for preoperative biliary decompression in patients with pancreatic cancer (ClinicalTrials.gov NCT01191814). In the absence of level-1 data, the panel consensus is that short, self-expanding metal stents are preferred because they are easy to place without dilation, are unlikely to interfere with the subsequent resection, and have a longer patency time than plastic stents. The panel cautions against placement of a metal stent prior to tissue proof of malignancy.

Effect of Clinical Volume

Several studies have examined the effect of institutional volume on patient outcomes. The fundamental premise was that the decreasing morbidity and mortality seen in the 1980s and 1990s were the direct result of large, single-institution experiences. Moreover, the concern was that if surgeons performed pancreatoduodenectomy less frequently, patients might have increased morbidity and mortality. A group from Memorial Sloan Kettering Cancer Center examined the issue in 1995 and found that in a cohort of almost 2000 patients, high-volume centers in New York State had significantly less mortality than low-volume centers (4% vs. 12.3%).⁴⁹³ High volume was defined as more than 50 cases per year, and this relationship correlated in a regression analysis. Of note, 75% of the cases in New York State were performed in low-volume centers. Several other studies have assessed regional outcomes with pancreatoduodenectomy from U.S. hospitals.⁴⁹⁴⁻⁴⁹⁸ These studies have reported decreased mortality, hospital length of stay, and overall cost at higher-volume centers (or with surgeons who perform the resections frequently) when compared with low-volume centers. Interestingly, this effect was also seen in reports from Canada and the Netherlands.⁴⁹⁹⁻⁵⁰¹

The definitions of high and low volume varied among all these studies. However, a striking difference was seen when the mortality rates from pancreatoduodenectomy in very-low-volume (0–1 procedure/year) and low-volume (1–2 procedures/year) hospitals were compared with rates in higher-volume hospitals (>5 procedures/year).⁵⁰² In-hospital mortality rates at these very-low-volume and low-volume hospitals were significantly higher than at high-volume hospitals (16% and 12%, respectively, vs. 4%; $P < .001$). The importance of hospital volume in improving survival after pancreatic cancer surgery is even more marked when pancreatoduodenectomy is compared to other major surgeries. In a retrospective analysis of data from the national Medicare claims

database and the Nationwide Inpatient Sample, hospitals performing 6 to 16 and greater than 16 procedures per year were classified as “high” and “very-high” volume centers.⁵⁰³ In this study, 6 or more pancreatic resections were performed at only 6.3% of hospitals. The largest difference in operative mortality between very-low-volume (16.3%) and high-volume (3.8%) centers was seen for pancreatoduodenectomy, as compared to major surgery at any other site, further reinforcing the magnitude of the effect that high-volume centers can have specifically on pancreatic cancer outcomes.

Furthermore, a study involving 301,033 patients with pancreatic adenocarcinoma included in the NCDB that evaluated the treatment patterns of 1667 hospitals over a 19-year period showed that patients were more likely to receive multimodality therapy at academic institutions considered to be high-volume hospitals.⁵⁰⁴ In addition, a systematic review showed that margin status correlates with hospital volume, with negative margin rates ranging from 55% in low-volume centers to 76% for very-high-volume centers ($P = .008$).⁵⁰⁵ This review also found that 5-year survival rates were higher in high-volume centers. In contrast, hospital readmission after pancreatoduodenectomy appears to be more of a function of patient characteristics than hospital or surgeon volume.⁵⁰⁶

The NCCN Panel recommendation is that pancreatic resections should be done at institutions that perform a large number (at least 15–20) of pancreatic resections annually.

Pathology

Progress in treating pancreatic adenocarcinoma is encumbered by a lack of uniformity among treating physicians in defined areas that include pathologic analysis and reporting.⁵⁰⁷ A more standardized approach in this area could maximize the chances of a more complete



and consistent pathology report that is similar among pathologists in the same institution and among institutions around the world. Ultimately, a more consistent approach to patient assessment, surgical technique, and pathologic evaluation of the resected pancreatic specimen from gross examination to pathologic report will provide better communication among the various treating physicians. It will also provide a clear and specific understanding of the individual patient's malignancy, including critical margin status, which will then allow a more accurate comparison of the existing and evolving treatment regimens for this lethal disease.

Specimen Orientation, Sectioning, Pathologic Analysis, and Reporting

The primary purpose of pathologic analysis of the pancreatic specimen is to determine the pathologic stage of the tumor by evaluating the type, grade, size, and extent of the cancer. Pathology synoptic reports (protocols) are useful for reporting results from examinations of surgical specimens; these reports assist pathologists in providing clinically useful and relevant information. In 2004, the Commission on Cancer (CoC) of the American College of Surgeons mandated the use of specific checklist elements of the protocols as part of its Cancer Program Standards for Approved Cancer Programs. The pathology synoptic reports from the College of American Pathologists (CAP) comply with the CoC requirements, and the latest revisions to the CAP Pancreatic (Exocrine) protocol were issued in October 2013.⁵⁰⁸ The NCCN Pancreatic Adenocarcinoma Panel currently supports the CAP pathology synoptic reports. The proposal included in the guidelines (see *Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting* in the Guidelines) is an abbreviated *minimum* analysis of pancreatic cancer specimens from the CAP recommendations. In addition to the standard TNM staging, other variables are included, all of which have prognostic implications in the evolution of this disease.^{509,510}

Lymph Node Counts and Lymph Node Ratio

The CAP recommendations include a count of the number of lymph nodes recovered and the number of involved nodes.⁵⁰⁸ Retrospective database analyses have found that patients with N0 disease have a better prognosis with an increasing number of examined lymph nodes.⁵¹¹⁻⁵¹³ These results suggest that a significant portion of patients with N0 disease might be understaged. Based on these data, groups have recommended the minimum number of lymph nodes examined to be from 11 to 17 to provide optimal staging and to serve as a quality indicator.^{511,513,514} The panel believes that every effort should be made to identify all regional lymph nodes within the pancreatectomy specimen.

For patients with N1 disease, lymph node ratio (positive node/nodes examined) appears to be related to prognosis.⁵¹¹⁻⁵¹⁸ For instance, in one analysis, patients with <15% of examined positive nodes had a 5-year survival rate of 21.7%, while those with greater than 15% positive nodes had a 5.2% 5-year survival rate ($P = .0017$).⁵¹⁶

Whipple Specimen

Specimen orientation and inking involves both a pathologist and surgeon, as this will help to ensure accurate assessment of the size and extent of the tumor. There should be either direct communication between the surgeon and pathologist for proper orientation and margin identification, or the surgeon should identify the important margins with a clearly understood and documented method (ie, written on the pathology requisition). For example, a stitch can be placed on the posterior margin and a safety pin on the retroperitoneal/uncinate margin.

One of the impediments to comparison of data across institutions is the variability in the names given to various margins. Definitions of the margins and uniformity of nomenclature are critical to accurate



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reporting. The panel's recommended definitions are included in the *Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting* section in the guidelines. Margins defined include the SMA (retroperitoneal/uncinate) margin, the posterior margin, the PV groove margin, the proximal and distal PV margins, the pancreatic neck (transection) margin, and the bile duct margin (see Figure 2). Other margins analyzed in Whipple specimens include the proximal and distal enteric margins (en face sections) and the anterior surface (closest representative). The anterior surface is not a true margin, but identification and reporting of this surface when positive may portend a risk of local recurrence, and so should be reported in all cases.^{507,519-521} Collectively, these pancreatic tissue surfaces constitute the circumferential transection margin. Designating the various specific margins with different colored inks will allow recognition on microscopy.

The approach to histologic sectioning of a Whipple specimen is determined by the unique characteristics of the tumor, but is also influenced by institutional preferences, expertise, and experience. There is no one correct way to dissect a Whipple specimen. Options include axial, bi- or multi-valve slicing, and perpendicular slicing (see Figure 3). Some experts in the field bisect the pancreas along probes placed in the bile and pancreatic ducts and then serially section along each half of the pancreas. Axial slicing provides an overall assessment of the epicenter of the tumor relative to the ampulla, bile duct, duodenum and pancreas, and all of the pancreatic circumferential tissue margins (see Figure 4).

The most important aspects of dissection are clear and accurate assessment of the margins. It is currently unknown what constitutes an adequate margin in pancreatic carcinoma resection specimens. A standardized definition of this would allow better stratification of patients into adjuvant regimens following surgical extirpation. For instance, if

less than 1-mm clearance is associated with an unacceptably high incidence of local recurrence, then strong consideration for postoperative radiation therapy (RT) might be indicated if not received preoperatively. The panel strongly recommends reporting tumor clearance in millimeters for all margins (as noted in the *Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting* section of the guidelines) to allow prospective accumulation of these important data for future analysis.

A recent retrospective review compared the outcomes of 169 patients with R0 resections of close margins (within 1 mm) to 170 patients with wider margins (>1 mm) and found an improvement in OS with wider margins (35 months vs. 16 months; $P < .001$).⁵²² In fact, patients with close-margin R0 resections had a median survival time similar to that of the R1 population (16 months vs. 14 months; $P = .6$). Consistent with these results, another retrospective review of 285 patients found that those with R1 resections, defined as tumor ≤ 1 mm from the margin, had a significantly worse local recurrence-free survival than those with R0 resections (HR, 4.27; 95% CI, 2.07–8.81).^{523,524} Finally, a recent study, which used a standardized pathologic protocol that involved multicolor inking and careful evaluation of multiple margins distances, found that patients with R1 resections (tumor at 0 mm) had a median survival of 17.7 months, while those with R0 resections had a median survival of 32.9 months ($P = .10$).⁵²⁵ Together, these results suggest that an appropriate definition of a negative margin may be greater than 1 mm.

Attached organs resected with the specimen en bloc require serial sectioning to assess not only direct extension, but metastatic deposits as well.

Distal Pancreatectomy Specimen

In left-sided resections, the peripancreatic soft tissue margins and the pancreatic neck are assessed (see Figure 5). Additionally, involvement of the splenic vessels should be documented, and invasion of the spleen is important to determine, because direct tumor invasion constitutes a pT3 pathologic stage. Frozen section analysis of the pancreatic neck is recommended. Definitions of the proximal pancreatic (transection) margin, the anterior (cephalad) peripancreatic (peripheral) surface, and the posterior (caudad) peripancreatic (peripheral) margin are included in the guidelines (see *Pathologic Analysis: Specimen Orientation, Histologic Sections, and Reporting* in the guidelines).

Perioperative Therapy

Even with R0 resections, recurrence rates are very high in this disease. Therefore, additional therapy is required for all patients with resected pancreatic adenocarcinoma.

Postoperative (Adjuvant) Therapy

Results of many trials have shown that adjuvant therapy improves outcomes over observation following resection (see sections on *Systemic Therapy Approaches* and on *Chemoradiation Approaches*, above). While results of RTOG 9704 cannot be directly compared with the results of the CONKO-001, ESPAC-1, or ESPAC-3 trials because of differences in treatment design, timing of imaging, and patient characteristics (eg, patients enrolled in CONKO-001 were more likely to be lymph node-negative and to have positive resection margins than those in RTOG 9704; and CONKO-001 excluded patients with high postoperative CA 19-9 or CEA levels²¹⁰), it is interesting to note that median OS for patients in the gemcitabine arm of CONKO-001 (22.8 months), the gemcitabine-containing arm of RTOG 9704 (20.5 months), the bolus 5-FU/leucovorin arm of ESPAC-1 (20.1 months), and the gemcitabine and 5-FU/leucovorin arms of the ESPAC-3 study (23.6 and

23.0 months) are remarkably similar. Results of the ESPAC-4 phase III randomized trial ($N = 730$), in which gemcitabine combined with capecitabine was compared to gemcitabine monotherapy for the adjuvant setting, showed that median survival was greater for participants randomized to receive the combination regimen (28.0 months), relative to patients randomized to receive gemcitabine monotherapy (25.5 months) (HR, 0.82; 95% CI, 0.68–0.98; $P = .032$).⁵²⁶ In the CONKO-005 phase III randomized trial, gemcitabine administered with erlotinib was compared to gemcitabine administered alone in the adjuvant setting.⁵²⁷ This combination regimen did not significantly improve OS or DFS, compared to gemcitabine monotherapy.

Based on the data discussed above, no definite standard has been established in the adjuvant treatment of pancreatic cancer at this time. Chemotherapy alone with gemcitabine (category 1), 5-FU/leucovorin (category 1), or continuous infusion 5-FU are listed in the guidelines as options for adjuvant treatment. It was the consensus of the panel that when chemotherapy alone is the choice of adjuvant therapy, gemcitabine is preferred over 5-FU/leucovorin for most patients due to its more favorable toxicity profile. In the adjuvant setting, capecitabine monotherapy is also listed in the guidelines (category 2B). The panel considers capecitabine to be a reasonable alternative to 5-FU/leucovorin only in this setting as a last choice in patients for whom other options are inappropriate or unacceptable. Gemcitabine, 5-FU/leucovorin, or continuous infusion 5-FU before and after gemcitabine- or fluoropyrimidine-based chemoradiation is also recommended as an adjuvant treatment. To date, no studies have demonstrated superiority of giving chemoradiation before versus after chemotherapy in the adjuvant setting.

Regardless of the therapy being considered it is important to evaluate the patient for extent of disease prior to therapy, because some patients



have early recurrence within the first few weeks following surgery. In addition, the panel recommends restaging a patient with imaging following systemic chemotherapy if chemoradiation is planned.

A recent retrospective analysis of data from patients in the ESPAC-3 trial found that completion of the full course of chemotherapy was an independent prognostic factor for survival, but that time to treatment initiation after surgery was not.⁵²⁸ These results suggest that delaying chemotherapy until patients adequately recover could possibly improve outcomes. The panel therefore recommends that adjuvant treatment be initiated within 12 weeks, after adequate recovery from surgery.

S-1 is an oral chemotherapy drug that is being used in Asia. Results of the phase III RCT JASPAC-01 trial ($N = 385$), in which S-1 was compared to gemcitabine in the adjuvant setting, showed that median OS was greater for S-1 (46.5 months; 95% CI, 37.8–63.7), compared to gemcitabine (25.5 months; 95% CI, 22.5–29.6).⁵²⁹ Three- and 5-year survival rates were 59.7% and 44.1%, respectively, for S-1, and 38.8% and 24.4%, respectively, for gemcitabine. S-1 was generally well-tolerated, and the treatment of patients randomized to receive gemcitabine was more likely to be discontinued, relative to the treatment of patients randomized to receive S-1 ($P = .005$). Grade 3 or 4 adverse events that were more likely to be reported in patients receiving gemcitabine include leucopenia, neutropenia, aspartate aminotransferase, and alanine aminotransferase, while stomatitis and diarrhea were more common in patients receiving S-1.

Ongoing clinical trials in the adjuvant setting include ESPAC-4 (www.controlled-trials.com/ISRCTN96397434), which is comparing gemcitabine with capecitabine to gemcitabine alone; RTOG 0848 (ClinicalTrials.gov NCT01013649), which is assessing gemcitabine with or without subsequent chemoradiation; a phase II study comparing

FOLFIRINOX with albumin-bound paclitaxel (ClinicalTrials.gov NCT02243007); the APACT study (ClinicalTrials.gov NCT01964430), comparing albumin-bound paclitaxel with gemcitabine; and the IMPRESS trial, which is comparing gemcitabine (with or without chemoradiation) with and without algenpantucel-L immunotherapy (ClinicalTrials.gov NCT01072981).

Preoperative (Neoadjuvant) Therapy

The standard approach to therapy in patients with resectable disease has been postoperative treatment, with median survivals in the range of 20.1 to 23.6 months under the most optimal clinical trial conditions.^{210,278,279,312} However, it is becoming increasingly apparent that patients with borderline resectable disease, who are at higher risk for R1 resections, are potentially in need of a different management approach. Contemporary approaches to perioperative treatment have focused on neoadjuvant therapy for patients with borderline resectable disease with the goal of improving OS.^{383,386} Neoadjuvant therapy is also sometimes used in patients with resectable disease, especially in those with high-risk features. The putative benefits of neoadjuvant therapy include increasing the likelihood that a higher proportion of patients with resectable disease will receive chemotherapy and/or radiation; the potential to downsize tumors so as to increase the likelihood of a margin-free resection (ie, conversion to resectable status); the potential to select for surgery those patients with more stable disease or disease that is more responsive to therapy; and the treatment of micrometastases at an earlier stage.^{385,387,401,530} Moreover, surgery following neoadjuvant treatment appears to be safe.^{531,532}

EUS-FNA is the preferred method of obtaining histologic confirmation of disease, and such confirmation is necessary before administering neoadjuvant therapy. A repeat biopsy should be performed in cases where the initial biopsy results do not confirm cancer. In addition,

staging laparoscopy, performed to evaluate for the possible presence of metastatic disease, can be considered before neoadjuvant therapy. Furthermore, patients for whom neoadjuvant therapy is planned should be assessed for jaundice, and placement of a stent (preferably a short, self-expanding metal stent [SEMS], as discussed in *Preoperative Biliary Drainage*, above) is recommended prior to initiation of neoadjuvant therapy in patients with jaundice.⁴⁸⁵⁻⁴⁸⁷

There is insufficient evidence to recommend specific neoadjuvant regimens, and practices vary with regard to chemotherapy and chemoradiation. Acceptable regimens include FOLFIRINOX or gemcitabine/albumin-bound paclitaxel. Subsequent chemoradiation is sometimes included. Studies of these regimens without chemoradiation are in progress. The role of chemoradiation with more active chemotherapy regimens also needs to be tested.

Pancreatic protocol CT or MRI of the abdomen and pelvis, and chest imaging (CT preferred) should be repeated following neoadjuvant therapy, and staging laparoscopy can be considered at this time if not previously performed. Surgical resection should only be attempted if there is a high likelihood of achieving an R0 resection. Surgery is ideally performed 4 to 8 weeks after therapy. Surgery can be performed more than 8 weeks following therapy, but radiation-induced fibrosis may potentially make surgery more difficult. Importantly, results from retrospective studies suggest that radiographic response does not correlate with pathologic response.^{533,534} Therefore, if no apparent tumor shrinkage is observed after neoadjuvant treatment and no extrapancreatic progressive disease is evident, surgery should still be attempted.

Neoadjuvant Therapy in Borderline Resectable Disease

Patients with borderline resectable disease should be considered for neoadjuvant therapy, followed by restaging and resection in patients without disease progression precluding surgery. The use of neoadjuvant therapy in the setting of borderline resectable disease has been a highly debated topic. However, although there is no high-level evidence supporting its use, most NCCN Member Institutions now prefer an initial approach involving neoadjuvant therapy, as opposed to immediate surgery, for patients with borderline resectable disease. In fact, upfront resection in patients with borderline resectable disease is no longer recommended, as of the 2016 version of these guidelines.

Several trials have shown that preoperative treatment of borderline resectable pancreatic adenocarcinoma can be effective and well-tolerated.⁵³⁵⁻⁵⁴⁰ A phase I/II trial of neoadjuvant therapy in borderline resectable disease allowed 4 of 26 patients (15%) to be resected.⁵³⁹ A randomized phase II trial comparing 2 different neoadjuvant regimens in borderline resectable disease was terminated early due to poor accrual, but 5 of 21 patients (24%) were resected.⁵³⁸ A recent multi-institutional phase II trial found that full-dose gemcitabine, oxaliplatin, and radiation given preoperatively to patients with resectable (n = 23), borderline resectable (n = 39), or unresectable disease (n = 6) found the approach to be feasible with an overall R0 resection rate of 53%.⁵³⁷ In this study, 63% of all evaluable patients underwent resection, with 84% of those patients achieving an R0 resection.

In 2 retrospective reviews, 31% to 35% of patients with borderline resectable disease who completed neoadjuvant therapy had R0 resections.^{541,542} A systematic review and meta-analysis of 19 cohort studies found that patients with unresectable disease (including both borderline resectable and unresectable) undergoing neoadjuvant chemoradiation therapy had similar 1-year survival outcomes as



patients who were initially deemed resectable.⁵⁴³ In this study, 40% of treated patients were ultimately resected.

It is important to note that no randomized phase III trials have compared the approach of neoadjuvant therapy in borderline resectable disease compared to the approach of taking these patients to surgery without initial therapy, and the best regimens to use in the borderline neoadjuvant setting are unknown. Several phase II clinical trials are currently underway to determine the R0 resection rate following neoadjuvant chemotherapy in patients with borderline resectable or unresectable locally advanced disease (eg, ClinicalTrials.gov NCT00557492). In addition, the Alliance A021101 trial (NCT01821612) is a single-arm pilot study evaluating the safety and efficacy of FOLFIRINOX before capecitabine-based chemoradiation and surgery in this population.⁴⁰² Initial results in patient series suggest that neoadjuvant regimens including FOLFIRINOX are a promising approach in patients with borderline resectable disease.^{544,545} Additional randomized trials are needed.

Neoadjuvant Therapy in Resectable Disease

A number of studies have evaluated the use of neoadjuvant chemoradiation in patients with resectable disease.^{385,386,546-554} A retrospective review of the collective experience at the University of Texas MD Anderson Cancer Center suggested that the use of preoperative chemoradiation therapy in patients with resectable disease is advantageous.⁵⁴⁷ The authors suggest that preoperative therapy gives a selection advantage because approximately 25% of patients who are restaged after therapy are found to have progressive disease and are therefore spared the morbidity of a surgical procedure that would not benefit them.⁵⁴⁷ In this analysis of 132 consecutive patients, the authors reported that combined preoperative chemoradiation and pancreatoduodenectomy yielded a median survival of 21 months, and

32% of patients were alive without evidence of disease at a median follow-up of 14 months.⁵⁴⁷ The MD Anderson group has continued to champion this approach both for its ability to select patients for resection and for cost-effectiveness.⁵⁵⁵ Other potential advantages of the neoadjuvant approach in patients with resectable disease have also been described, including sterilization of the field before resection potentially reducing spread during surgery; increased rates of R0 resections; decreased incidence of pancreatic fistulas; prevention of delays or reductions of adjuvant therapy after surgery; and improved delivery of chemotherapy and radiosensitizing oxygenation.^{532,556,557}

Although most studies investigating the neoadjuvant experience in patients with resectable pancreatic cancer are retrospective, several small phase II studies have been published.^{532,556,558,559} In a randomized phase II trial evaluating the safety and efficacy of gemcitabine-based chemotherapy regimens as neoadjuvant therapy for patients with resectable pancreatic cancer, more patients receiving gemcitabine with cisplatin were able to undergo resection compared with those in the gemcitabine-only arm.⁵⁵²

In a prospective trial, preoperative radiation with concurrent gemcitabine was administered to 86 patients with resectable disease, and patients were restaged 4 to 6 weeks following completion of neoadjuvant treatment.⁵⁴⁹ Although all patients were able to complete neoadjuvant therapy, at the time of restaging, only 73 (85%) patients were able to undergo surgery; the majority of the remaining patients were precluded from undergoing a pancreatoduodenectomy due to the presence of more advanced disease. Similar results were observed in another phase II trial involving preoperative gemcitabine/cisplatin followed by gemcitabine-based chemoradiation.⁴⁸⁶ In this study, which enrolled 90 patients, 79 patients were able to complete neoadjuvant therapy, and 52 patients underwent surgery. Again, the main reason patients were

precluded from surgery was the finding of more advanced disease at restaging following completion of neoadjuvant therapy. A cross-study comparison of these results suggests that inclusion of preoperative chemotherapy prior to initiation of gemcitabine-based chemoradiation did not improve survival.⁵³⁰ These results provide support for restaging patients with abdominal (pancreas protocol), pelvic, and chest imaging and diagnostic laparoscopy before committing them to laparotomy after neoadjuvant therapy.

Although evidence suggests that there may be a better chance of margin-negative resection with preoperative therapy,⁵⁶⁰ results of randomized trials addressing this issue are needed. A recent randomized phase II trial, which was terminated early because of slow accrual, compared gemcitabine/cisplatin neoadjuvant chemoradiation with upfront surgery; both arms received adjuvant chemotherapy.⁵⁶¹ With only 66 patients eligible for analysis, no significant differences were seen in R0 resection rate (52% vs. 48%), (y)pN0 rate (39% vs. 30%), or OS (25.0 months vs. 18.9 months), although all results favored the neoadjuvant arm and no safety issues were noted. The phase III NEOPA trial, with OS as the primary endpoint, is currently recruiting patients with resectable pancreatic cancer to compare neoadjuvant gemcitabine chemoradiation therapy to upfront surgery in this population (ClinicalTrials.gov NCT01900327).⁵⁶² A phase II trial with R0 resection as the primary endpoint is also ongoing (ClinicalTrials.gov NCT01389440).

At this time, the panel does not recommend neoadjuvant therapy for clearly resectable patients without high-risk features, except in a clinical trial. For selected patients who appear technically resectable but have poor prognostic features (ie, markedly elevated CA 19-9; large primary tumors; large regional lymph nodes; excessive weight loss; extreme

pain) consideration can be given to neoadjuvant therapy after biopsy confirmation.

Adjuvant Treatment After Neoadjuvant Therapy

For patients who received neoadjuvant treatment, data supporting additional therapy after surgery are lacking. The consensus of the panel is that patients who have received neoadjuvant chemoradiation or chemotherapy may be candidates for additional chemotherapy following surgery and multidisciplinary review. When chemotherapy is given, the choice of regimen may be based on response seen to neoadjuvant therapy and other clinical considerations, such as performance status and patient tolerability.

Adjuvant chemotherapy or adjuvant chemoradiation should only be considered for pre-treated patients who have adequately recovered from surgery and have no evidence of recurrence or metastatic disease; treatment should ideally be initiated within 4 to 8 weeks. It is recommended that the patient undergo a pretreatment baseline assessment following surgery, including CT scan and CA 19-9 level, to evaluate for the presence of metastatic disease before adjuvant chemoradiation is initiated. Further, the panel recommends restaging a patient with imaging following systemic chemotherapy, if it will precede chemoradiation.

Surveillance of Patients with Resected Disease

Although data on the role of surveillance in patients with resected pancreatic adenocarcinoma are very limited,⁵⁶³⁻⁵⁶⁵ recommendations are based on the consensus that earlier identification of disease may facilitate patient eligibility for investigational studies or other forms of treatment. The panel recommends history and physical examination for symptom assessment every 3 to 6 months for 2 years, then every 6 to 12 months. CA 19-9 determinations and follow-up CT scans every 3 to



6 months for 2 years after surgical resection are category 2B recommendations, because data are not available to show that earlier treatment of recurrences, following detection by increased tumor marker levels or CT scan, leads to better patient outcomes. In fact, an analysis of the SEER-Medicare database showed no significant survival benefit for patients who received regular surveillance CT scans.⁵⁶⁶

Management of Recurrent Disease After Resection

As cross-sectional body imaging has improved, small-volume metastatic disease or local recurrence is being detected in patients with resected pancreatic cancer who are otherwise maintaining good functional status. As many as 50% of them will continue to maintain a sufficiently good performance status to consider second-line therapy.⁵⁶⁷ These patients will, however, ultimately progress.

For patients experiencing a recurrence of disease following resection, the panel recommends consideration of confirmatory biopsy (category 2B). In all cases of recurrent disease, a clinical trial is the preferred option; palliative and best supportive care without additional therapy should also be an option, especially for patients with poor performance status. Alternatively, chemoradiation can be considered in patients with local disease recurrence only, if not previously administered, or an alternative chemotherapy regimen can be given. For patients with local disease recurrence, surgical resection may be considered in select cases (ie, good performance status, location of recurrence is favorable), though there is currently no evidence to support this recommendation. For patients for whom there is evidence of metastatic disease (with or without a local recurrence), treatment decisions are influenced by the length of time from completion of adjuvant therapy to the detection of metastases. If adjuvant therapy was completed less than 6 months prior to development of metastatic disease, the panel recommends that an

alternative chemotherapy option be administered. When this period is greater than 6 months, systemic therapy as previously administered or an alternative systemic regimen is recommended. Recommended regimens for patients with previous adjuvant treatment and good performance status are gemcitabine/albumin-bound paclitaxel and FOLFIRINOX.

Management of Isolated Pulmonary Metastases

Some patients have isolated lung metastases after resection of localized pancreatic adenocarcinoma. A growing body of evidence in this population suggests that these patients have a prolonged survival compared to patients with metastases in other locations.^{568,569} Preliminary data also suggest that pulmonary metastasectomy may be advantageous in this population.⁵⁷⁰ More data are needed before recommendations can be made regarding the management of pulmonary metastases of pancreatic cancers.

Palliative and Supportive Care

A significant subset of patients with pancreatic cancer will require substantial palliative interventions that are, in many respects, unique to the disease. The multidisciplinary management of symptoms due to biliary obstruction, gastric outlet obstruction, and cancer-related pain is of primary importance. The main objective of palliative care is to prevent and ameliorate suffering while ensuring optimal quality of life. Palliative surgical procedures are best reserved for patients with longer life expectancies.

Biliary Obstruction

Approximately 65% to 75% of patients with pancreatic cancer develop symptomatic biliary obstruction.⁵⁷¹ For patients diagnosed with unresectable disease and biliary obstruction upon initial evaluation, the



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best palliation is provided by an endoscopic biliary stent, especially when anticipated survival is limited. In most cases, a permanent SEMS is recommended unless biliary bypass is performed (also see the discussion on stents in *Preoperative Biliary Drainage*, above). Stent occlusion that causes recurrent cholangitis is a well-known complication of plastic (temporary) biliary stents and typically occurs within 3 months of insertion. Metal stents are wider in diameter than plastic stents (ie, less likelihood of blockage) and become embedded in the bile duct, whereas plastic stents are more likely to become occluded but can be replaced. Results of an RCT of 100 patients at a single center randomly assigned to receive either a plastic stent or a covered SEMS inserted endoscopically indicated that median patency times were 1.8 and 3.6 months ($P = .002$), respectively.⁵⁷² A meta-analysis comparing metal and plastic biliary stents placed endoscopically in patients with pancreatic adenocarcinoma characterized by biliary obstruction showed similar results.⁵⁷³ This study suggested that the risk of recurrent biliary obstruction was lower for the metal stents (RR, 0.52; 95% CI, 0.39–0.69), although no significant differences in technical/therapeutic success, complications, or 30-day mortality were found. Another recent randomized trial showed that covered SEMS had longer patency than uncovered SEMS in the setting of biliary obstruction due to pancreatic cancer, because covered stents prevented the ingrowth of tumor.⁵⁷⁴

When a biliary stent cannot be placed (often because the endoscope cannot be advanced past the neoplasm that is obstructing the gastric outlet), percutaneous biliary drainage with subsequent internalization may be necessary. An alternative is to sequentially dilate the duodenum endoscopically, place a metallic biliary stent, and then place an enteral stent.⁵⁷⁵ Durable palliation of biliary obstruction can often be achieved with an expandable metallic biliary endoprosthesis (eg, Wallstent, Boston Scientific) in this situation.⁵⁷⁵

For patients with jaundice and potentially resectable disease who are found to have unresectable tumors following laparotomy, an open biliary-enteric bypass provides durable palliation of biliary obstruction and can be combined with procedures that palliate symptoms resulting from gastric outlet obstruction and cancer-related pain. The panel recommends stenting or an open biliary-enteric bypass with or without gastrojejunostomy (category 2B for prophylactic gastrojejunostomy^{576,577}) and with or without celiac plexus neurolysis⁵⁷⁸⁻⁵⁸⁰ (category 2B in patients without jaundice). See *Gastric Outlet Obstruction and Severe Tumor-Associated Abdominal Pain* below for more detailed information on these procedures. Bypass of the common bile duct (choledochojejunostomy) or common hepatic duct (hepaticojejunostomy) to the jejunum is preferred to bypass of the gallbladder (cholecystojejunostomy) since choledochojejunostomy/hepaticojejunostomy provide more durable and reliable palliation of biliary obstruction.⁵⁷¹

Biliary decompression is also required for jaundiced patients with disease progression precluding surgery with or without neoadjuvant therapy. Here, stenting or biliary bypass is recommended, with or without gastrojejunostomy (category 2B for prophylactic gastrojejunostomy^{576,577}) and with or without celiac plexus neurolysis (category 2B). One final circumstance requiring biliary drainage is in jaundiced patients with locally advanced or metastatic disease (those for whom surgical resection will not be attempted). In this situation, a SEMS is preferred unless biliary bypass was performed at the time of laparoscopy or laparotomy. If cancer has not been biopsy-confirmed in the setting of locally advanced disease in a patient with jaundice, brushings can be obtained at the time of stent placement.

Gastric Outlet Obstruction

Symptomatic gastric outlet obstruction occurs in 10% to 25% of patients with pancreatic cancer.⁵⁷¹ Patients with locally advanced or metastatic disease and a short life expectancy or poor performance status who develop gastric outlet obstruction may be palliated with an endoscopically placed enteral stent after biliary drainage is assured.⁵⁷⁵ An alternative for these patients with poor performance status is percutaneous endoscopic gastrostomy (PEG) tube placement. For a fit patient with a life expectancy greater than 3 to 6 months (ie, locally advanced disease) who develops gastric outlet obstruction, an open or laparoscopic gastrojejunostomy (duodenal bypass) with or without a jejunostomy (J) tube should be considered since it may provide more durable and effective palliation of gastric outlet obstruction than an enteral stent.⁵⁸¹⁻⁵⁸³ Nevertheless, placement of an enteral stent is also an option for these patients.

For patients with potentially resectable disease who undergo a laparotomy and are found to have unresectable disease, a prophylactic gastrojejunostomy should be performed for those deemed to be at risk of developing symptomatic gastric outlet obstruction (category 2B). The role of prophylactic gastrojejunostomy in otherwise asymptomatic patients who are found to have unresectable cancers at the time of laparotomy has been evaluated. Two RCTs have investigated the role of prophylactic gastrojejunostomy for unresectable periampullary cancer, the majority arising from the head of the pancreas.^{576,577} In both studies, approximately 20% of patients who did not undergo a prophylactic gastrojejunostomy developed late gastric outlet obstruction that required therapy. A recent meta-analysis found similar results, with development of gastric outlet obstruction in 2.5% of patients in the prophylactic gastrojejunostomy group and 27.8% of those not receiving gastrojejunostomy.⁵⁸⁴ In both studies, prophylactic retrocolic

gastrojejunostomy significantly decreased the incidence of late gastric outlet obstruction but did not extend the length of stay or increase complication rates, such as delayed gastric emptying.

Severe Tumor-Associated Abdominal Pain

Most patients with locally advanced or metastatic pancreatic cancer experience cancer-related pain.⁵⁸⁰ General principles for cancer-related pain management can be found in the NCCN Guidelines for Adult Cancer Pain (available at www.NCCN.org). Patients with severe tumor-associated abdominal pain should be treated with around-the-clock narcotics. However, some patients will be unresponsive to narcotics or will experience undesirable side effects. Because advanced pancreatic cancer often infiltrates the retroperitoneal nerves of the upper abdomen, celiac plexus neurolysis should be considered (category 2B, except when indicated by pain in a patient with jaundice who is found unresectable at surgery, for which the recommendation is a category 2A). In several RCTs, celiac plexus neurolysis significantly improved pain relief in patients with advanced pancreatic cancer.^{578,580,585} In a study of 96 patients with pain related to suspected pancreatic cancer, half were randomized to EUS-guided celiac plexus neurolysis at the time of EUS if unresectable adenocarcinoma was confirmed.⁵⁷⁹ These patients reported better pain relief at 3 months ($P = .01$), suggesting that early EUS-guided celiac plexus neurolysis may be beneficial. A recent meta-analysis of 7 RCTs concluded that celiac plexus neurolysis improved pain scores at 4 weeks but not at 8 weeks in patients with pancreatic cancer.⁵⁸⁶ The effectiveness of ethanol celiac plexus neurolysis for pain in resectable pancreatic and periampullary adenocarcinoma was examined in a recent RCT ($N = 467$).⁵⁸⁷ The use of this technique was not found to significantly impact postoperative pain. Minimally invasive techniques including EUS-guided (preferred if available) and percutaneous fluoroscopic- or CT-guided celiac plexus



neurolysis are recommended, but laparoscopic, thoracoscopic, and open approaches can also be used.

In selected patients with severe local back pain refractory to narcotic therapy, palliative RT may be considered, even in the setting of metastatic disease, if not already given as part of primary therapy. In such cases, radiation is given with or without concurrent chemotherapy to the primary tumor plus a margin (typically 25–36 Gy in 2.4–5 Gy fractions), or radiation alone is given to the metastatic site.

Pancreatic Exocrine Insufficiency

Exocrine enzyme insufficiency in pancreatic cancer is caused by tumor-induced damage to the pancreatic parenchyma and/or blockage of the pancreatic duct, or by surgical removal of pancreatic tissue, and results in an inadequate production of digestive enzymes.^{588,589} This deficiency in pancreatic enzymes results in inadequate absorption of fat, carbohydrates, and proteins, leading to steatorrhea, abdominal cramps, weight loss, and malnutrition.⁵⁹⁰ Oral pancreatic exocrine enzyme replacement therapy is recommended for patients with pancreatic cancer who have symptoms of exocrine enzyme deficiency. Because pancreatic exocrine insufficiency occurs in up to 94% of patients undergoing pancreatic surgery,^{591,592} therapy may be initiated without diagnostic tests. Enteric-coated mini-microspheres containing preparations of pancreatic enzymes are taken orally (25,000–75,000 units of lipase for a main meal and 10,000–25,000 units of lipase for a snack, depending on fat content), with half of the dose taken at the start of the meal and half taken in the middle of the meal.⁵⁹⁰ For patients with disease that does not respond to this therapy, doses of the enzyme preparation can be increased, and inhibition of gastric secretion with a proton pump inhibitor can also be considered.^{590,591} Patients with a clinical suspicion of pancreatic exocrine insufficiency despite

appropriate replacement may need a more thorough nutritional evaluation.

Thromboembolic Disease

The risk of developing venous thromboembolic disease is substantially increased in patients with pancreatic cancer.^{593,594} The panel recommends low-molecular-weight heparin (LMWH) as preferred therapy over warfarin for patients with pancreatic cancer who develop a venous thromboembolism (VTE). Support for this recommendation comes from results of 2 large, prospective, randomized clinical trials: CLOT and CONKO 004. In the CLOT study, an approximately 2-fold decrease in the incidence of recurrent VTE at 6 months was observed in patients with advanced or metastatic cancer diagnosed with a VTE who were treated with the LMWH, dalteparin, compared with those treated with an oral anticoagulant.⁵⁹⁵

Results from the CONKO 004 trial showed that patients randomized to receive enoxaparin ($n = 160$) experienced fewer symptomatic VTEs, relative to patients receiving chemotherapy only ($n = 152$) (HR, 0.40; 95% CI, 0.19–0.83; $P = .01$).⁵⁹⁶ PFS and OS did not significantly differ between the two groups, however. In a pilot trial conducted in preparation for the CONKO 004 trial, the risk of developing symptomatic VTE was significantly lower for patients in the LMWH arm of the study with no significant increase in bleeding observed in this group compared to those not receiving enoxaparin.⁵⁹⁷ The panel does not recommend prophylactic LMWH at this time, due to the lack of evidence regarding impact on survival. Please see the NCCN Guidelines for Cancer-Associated Venous Thromboembolic Disease for more information (available at www.NCCN.org).

Depression, Pain, and Malnutrition

For many patients, a diagnosis of pancreatic cancer may result in significant psychosocial distress, including anxiety, depression, and sleep disturbances.⁵⁹⁸ In fact, the suicide rate in male patients with pancreatic cancer is reportedly 11 times that of the general population.⁵⁹⁹ Empathetic discussion about the natural history of this disease and its prognosis and the provision of support and counseling both by the primary oncology team and specialized services may help to alleviate this distress. The panel recommends that patients be screened and evaluated for depression and other psychosocial problems following the NCCN Guidelines for Distress Management (available at www.NCCN.org).

Because pain and malnutrition are also prevalent in patients with pancreatic cancer, the panel recommends that patients with locally advanced or metastatic pancreatic cancer receive a nutritional evaluation and a formal evaluation by a Palliative Medicine Service, when appropriate. Additional resources are detailed in the NCCN Guidelines for Palliative Care and the NCCN Guidelines for Adult Cancer Pain (available at www.NCCN.org).

Future Clinical Trials: Recommendations for Design

In 2007, a meeting was convened by the National Cancer Institute's Gastrointestinal Cancer Steering Committee in recognition of the failure of a number of phase III trials to show clinically significant benefit for patients with pancreatic cancer and to address the importance of integrating basic and clinical knowledge in the design of clinical trials in pancreatic cancer. Meeting participants included representatives from industry, government, and the community, as well as academic researchers and patient advocates. Several important themes emerging from this meeting are summarized below, and the recommendations put

forward by the committee are endorsed by the NCCN Pancreatic Adenocarcinoma Panel.⁶⁰⁰

- With the emergence of new agents to treat pancreatic cancer, particularly biologics, clinical trial strategies incorporating principles of molecular biology and new imaging methods as well as results from preclinical studies are important.
- For patients enrolled in clinical trials, banking of tumor tissue samples should be required along with paired blood and serum samples.
- Biomarkers that serve as surrogate markers of the anticancer effects of investigational agents should be sought, and assays to measure such biomarkers should be well validated.
- Clinical trials should enroll homogeneous patient populations with respect to disease stage (ie, separate trials for patients with locally advanced disease and metastatic disease) and patient performance status. Criteria for selecting study populations should take into account the putative differential efficacy of the agent (ie, vaccines in patients with early-stage disease).
- Phase III trials should not be initiated in the absence of clinically meaningful efficacy and safety signals in the phase II setting.
- Phase II and III clinical trials should have a primary endpoint of OS.
- Quality control standards for preoperative imaging interpretation, pathologic assessment of tumor specimens, and surgical selection criteria are critical when evaluating adjuvant therapies.

A 2011 consensus report from a group of European experts came to many of the same conclusions.⁶⁰¹ Additionally, the group states that



FOLFIRINOX can be considered as a new standard treatment option in selected patients in future clinical trials, but that gemcitabine should remain the standard for most patients. An international expert panel also met to discuss current and future pancreatic cancer research and came to similar conclusions.⁵⁶⁷ In addition, the Intergroup Pancreatic Cancer Task Force's Tissue Acquisition Working Group has made recommendations regarding the prospective collection and sharing of tissue to accelerate the discovery of predictive and prognostic biomarkers.⁶⁰² These recommendations include centralization of biorepositories and mandatory collection of tissue (when there is sufficient material), blood, serum, and plasma in all phase III trials.

ASCO also recently convened a working group to discuss designs for pancreatic cancer clinical trials that would accomplish meaningful clinical improvements.⁶⁰³ This group concluded OS should be the primary endpoint of first-line, metastatic pancreatic cancer trials. They also concluded that trials should aspire to a 3- to 4-month improvement in OS in gemcitabine-eligible and gemcitabine/albumin-bound paclitaxel-eligible patients and a 4- to 5-month improvement in OS for FOLFIRINOX-eligible patients to give results with true clinical impact.

To determine appropriate historic controls for single-arm phase II trials based on gemcitabine, an algorithm has been developed, based on an analysis of a database of cooperative group trials, that can be used to calculate historic benchmarks for OS and PFS.⁶⁰⁴

Neoadjuvant Clinical Trials

For neoadjuvant trials, study populations should be well defined and standardized. The panel endorses use of a restrictive definition of borderline resectable disease in clinical trials, such as that defined in a recent Intergroup trial.⁴⁰² Endpoints should also be standardized and

could include resection rates, R0 resection rates, local recurrence rates, pathologic response rates, DFS, and OS.⁶⁰⁵

Targeted Therapies

Poly (ADP-ribose) polymerase (PARP) inhibitors provide a promising avenue of treatment for cancers associated with *BRCA1/2* mutations.⁶⁰⁶ In a phase II trial assessing the efficacy and safety of olaparib, an oral PARP, the tumor response rate for patients with metastatic pancreatic cancer and a germline *BRCA1/2* mutation ($n = 23$) was 21.7% (95% CI, 7.5–43.7).⁶⁰⁷ The PARP inhibitor rucaparib is being assessed in the ongoing RUCAPAN trial, targeting patients with a *BRCA1/2* mutation (NCT02042378). Data from a phase II trial including 19 patients with a *BRCA1/2* mutation and relapsed disease showed an objective response rate of 11%.⁶⁰⁸ The phase III randomized POLO trial (NCT02184195), in which the effectiveness of maintenance olaparib monotherapy following cisplatin, carboplatin, or oxaliplatin is being assessed, is currently in process.

Summary

Resection remains the only chance for a cure for pancreatic adenocarcinoma, and most resectable patients should undergo surgery without delay, followed by adjuvant therapy. Patients with borderline resectable disease and select patients with resectable disease can undergo neoadjuvant therapy in the hopes of improving the chances for an R0 resection or can immediately undergo surgery. Additional therapy is an option for those patients whose disease recurs following surgery. Patients with locally advanced unresectable disease and good performance status can undergo chemotherapy and chemoradiation with second-line therapy if performance status is maintained after progression. Patients with good performance status presenting with metastatic disease can undergo chemotherapy and can undergo



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second-line therapy if performance status is maintained after progression. Specific palliative measures are recommended for patients with advanced pancreatic adenocarcinoma characterized by biliary or gastric obstruction, severe abdominal pain, or other tumor-associated manifestations of the disease.

Overall, in view of the relatively high likelihood of poor outcomes for patients with all stages of pancreatic cancer, the NCCN Panel recommends that investigational options be considered in all phases of disease management.

Table 1: Selected Genetic Syndromes with Associated Pancreatic Cancer Risk

Syndrome	Gene	Estimated cumulative risk of pancreatic cancer	Estimated increased risk compared to general population
Peutz-Jeghers Syndrome	<i>STK11</i>	11%–36% by age 65–70 years ⁷¹	132-fold ⁷⁰
Familial Pancreatitis	<i>PRSS1</i> , <i>SPINK1</i> , <i>CFTR</i>	40%–53% by age 70–75 years ⁷⁵⁻⁷⁷	26-fold to 87-fold ^{36,75-77}
Melanoma-Pancreatic Cancer Syndrome	<i>CDKN2A</i>	14% by age 70 ⁸³ 17% by age 75 years ⁸⁰	20-fold to 47-fold ^{79,80}
Lynch Syndrome	<i>MLH1</i> , <i>MSH2</i> (<i>MSH6</i>)	4% by age 70 years ⁹¹	9-fold to 11-fold ^{91,92}
Hereditary Breast-Ovarian Cancer Syndrome	<i>BRCA1</i> , <i>BRCA2</i>	1.4%–1.5% (women) and 2.1%–4.1% (men) by age 70 ^{94,99}	2.4-fold to 6-fold ^{94,98,99}
Familial Pancreatic Cancer	Unknown in most families (family X is an exception)*	≥3 first-degree relatives with pancreatic cancer: 7%–16% by age 70 ⁶² 2 first-degree relatives with pancreatic cancer: 3% by age 70 ⁶²	≥3 first-degree relatives with pancreatic cancer: 32-fold ⁶⁶ 2 first-degree relatives with pancreatic cancer: 6.4-fold ⁶⁶ 1 first-degree relative with pancreatic cancer: 4.6-fold ⁶⁶

*One family (family X) with a mutation in the *palladin* (*PALLD*) gene has been identified.⁶⁰⁹



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Table 2: Potential Indications for Various Therapies in the Treatment of Pancreatic Adenocarcinoma

Regimen	Resectable (adjuvant)	Borderline Resectable (neoadjuvant)	Locally Advanced	Metastatic (category recommendations for good performance status only unless otherwise noted)	Second-Line Therapy (good performance status only)
Gemcitabine	√ (category 1)		√ (category 1 for poor performance status)	√ (category 1 for good and poor performance status)	√ (if previously treated with fluoropyrimidine-based therapy)
Gemcitabine/Albumin-Bound Paclitaxel		√	√	√ (category 1; preferred)	√ (if previously treated with fluoropyrimidine-based therapy)
Gemcitabine/Erlotinib			√	√ (category 1; survival benefit is small)	√ (if previously treated with fluoropyrimidine-based therapy)
Gemcitabine/Cisplatin			√ (as an alternative to FOLFIRINOX in patients with hereditary cancers)	√ (as an alternative to FOLFIRINOX in patients with hereditary cancers)	√ (if previously treated with fluoropyrimidine-based therapy)
Gemcitabine/Capecitabine			√	√	√ (if previously treated with fluoropyrimidine-based therapy)
Fixed-dose-rate Gemcitabine			√	√ (category 2B)	√ (if previously treated with fluoropyrimidine-based therapy)
GTX [Fixed-dose-rate gemcitabine/docetaxel/capecitabine]			√ (category 2B)	√ (category 2B)	√ (if previously treated with fluoropyrimidine-based therapy)
5-FU/Leucovorin	√ (category 1)				√ (if previously treated with gemcitabine-based therapy)



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5-FU/ Leucovorin/Liposomal Irinotecan					√ (category 1, if previously treated with gemcitabine-based therapy)
FOLFIRINOX		√	√	√ (category 1; preferred)	√ (if previously treated with gemcitabine-based therapy)
Capecitabine	√ (category 2B)		√ (category 2B)	√ (category 2B)	√ (if previously treated with gemcitabine-based therapy)
Continuous Infusion 5-FU	√		√ (category 2B)	√ (category 2B)	√ (if previously treated with gemcitabine-based therapy)
Fluoropyrimidine/ Oxaliplatin (eg, FOLFOX, CapeOx)			√ (category 2B)	√ (category 2B)	√ (if previously treated with gemcitabine-based therapy)
Radiation	√ (fluoropyrimidine- or gemcitabine-based, after and followed by gemcitabine, 5-FU/leucovorin, or continuous infusion 5-FU)	√ (subsequent chemoradiation is sometimes included)	√ (in select patients without systemic metastases; fluoropyrimidine- or gemcitabine-based and preferably following a course of chemotherapy)		√ (palliative only)

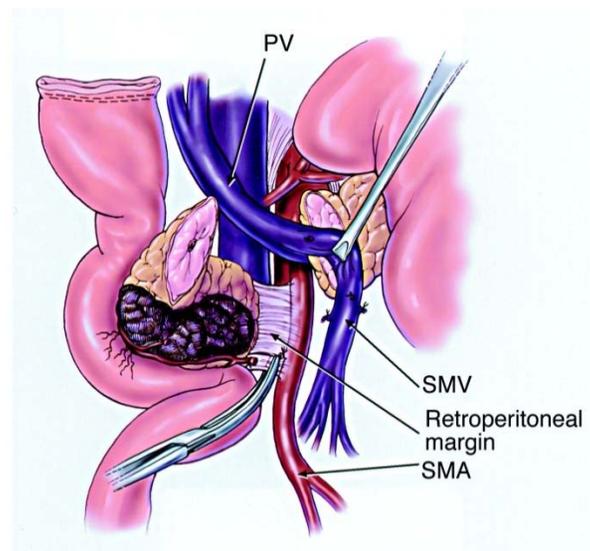


Figure 1. Complete mobilization of the superior mesenteric (SMV) and portal veins, and separation of the specimen from the right lateral border of the superior mesenteric artery (SMA).⁶¹⁰

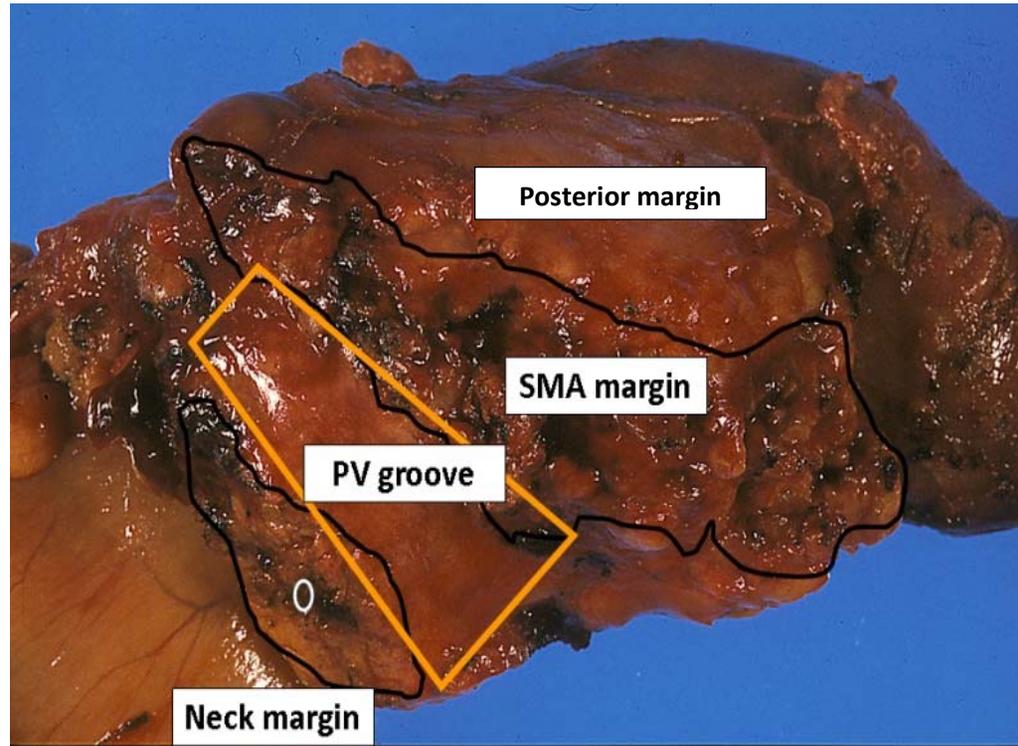
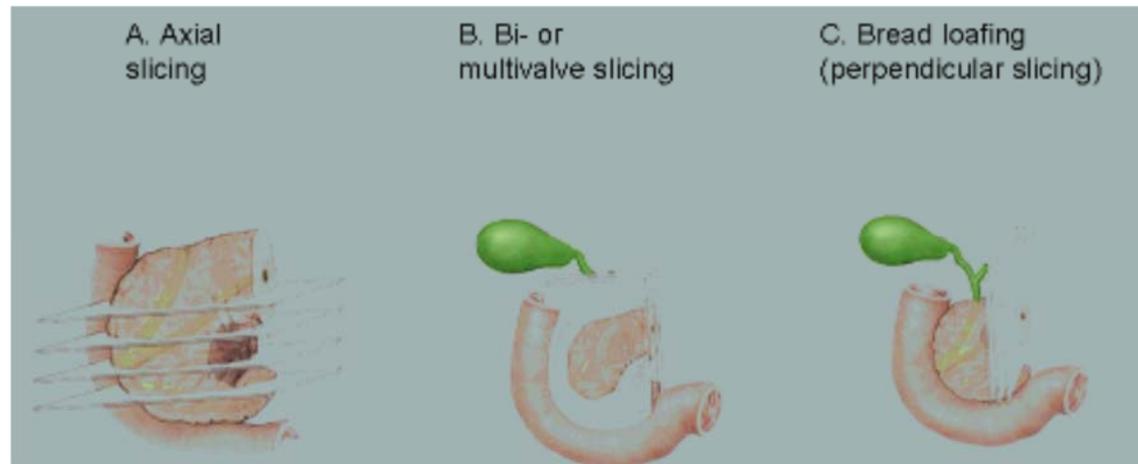


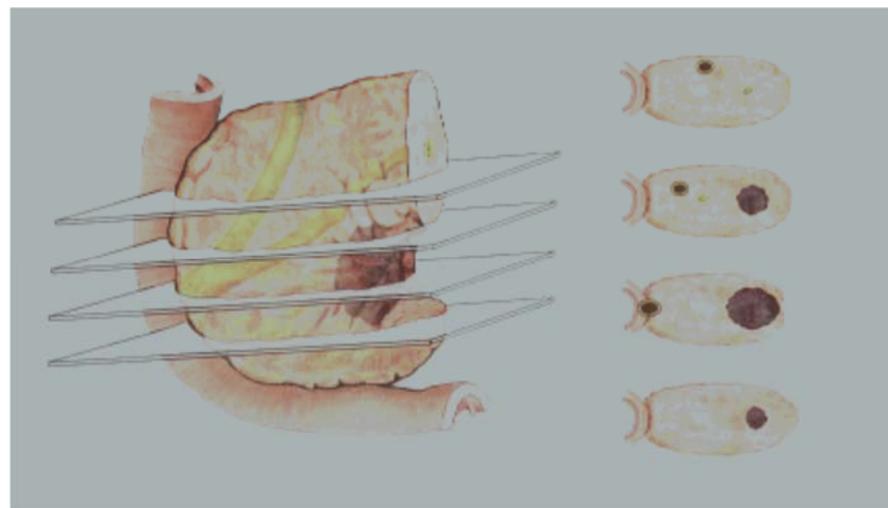
Image courtesy of Dr. N. Volkan Adsay

Figure 2. Whipple specimen with labeled margins.



Courtesy of Mr. Paul Brown, Specialist Medical Illustrator, St James's University Hospital Leeds

Figure 3. Slicing of pancreatoduodenectomy specimens.⁵⁰⁷



Courtesy of Mr. Paul Brown, Specialist Medical Illustrator, St James's University Hospital Leeds

Figure 4. Slicing of the pancreatoduodenectomy specimen in the axial plane to allow circumferential assessment of tumor.⁵⁰⁷

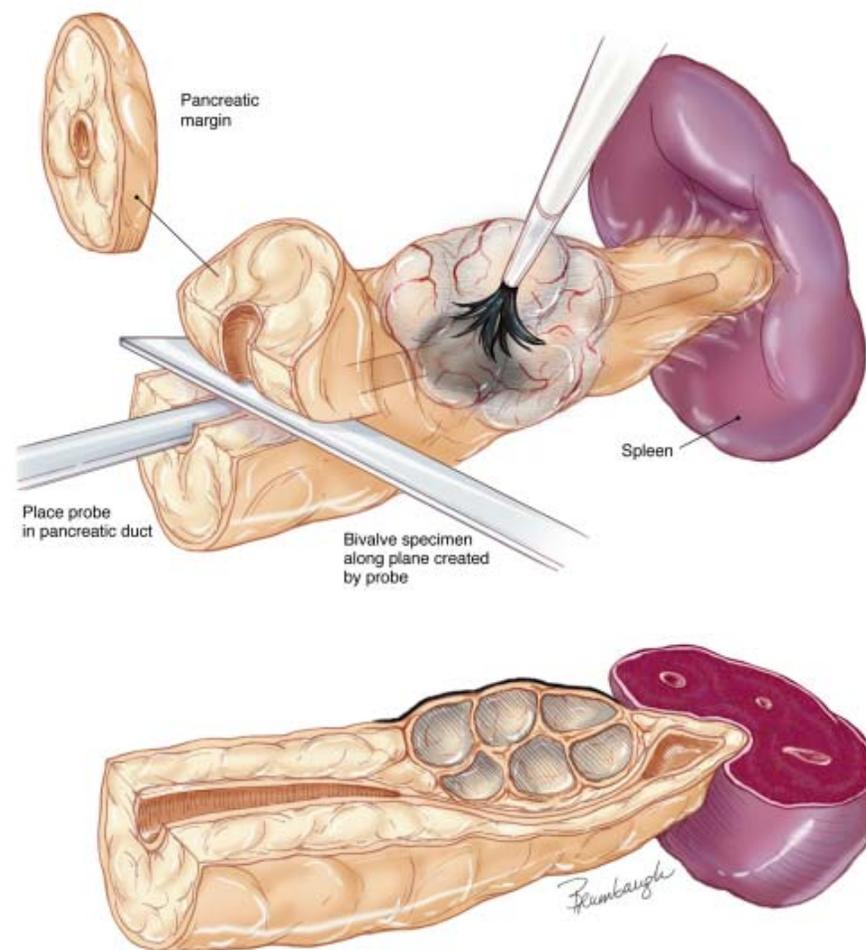


Figure 16-4, from Hruban, Ralph et al. Tumors of the Pancreas: Afip Atlas of Tumor Pathology, American Registry of Pathology, Washington DC 2007

Figure 5. Slicing of the distal pancreatectomy specimen.⁵²¹

References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. *CA Cancer J Clin* 2016;66:7-30. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26742998>.
2. Arnold LD, Patel AV, Yan Y, et al. Are racial disparities in pancreatic cancer explained by smoking and overweight/obesity? *Cancer Epidemiol Biomarkers Prev* 2009;18:2397-2405. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19723915>.
3. Simard EP, Ward EM, Siegel R, Jemal A. Cancers with increasing incidence trends in the United States: 1999 through 2008. *CA Cancer J Clin* 2012. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22281605>.
4. Ehemann C, Henley SJ, Ballard-Barbash R, et al. Annual Report to the Nation on the status of cancer, 1975-2008, featuring cancers associated with excess weight and lack of sufficient physical activity. *Cancer* 2012;118:2338-2366. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22460733>.
5. Smith BD, Smith GL, Hurria A, et al. Future of cancer incidence in the United States: burdens upon an aging, changing nation. *J Clin Oncol* 2009;27:2758-2765. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19403886>.
6. StatBite. U.S. pancreatic cancer rates. *J Natl Cancer Inst* 2010;102:1822. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21139097>.
7. Worni M, Guller U, White RR, et al. Modest improvement in overall survival for patients with metastatic pancreatic cancer: a trend analysis using the surveillance, epidemiology, and end results registry from 1988 to 2008. *Pancreas* 2013;42:1157-1163. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23867367>.
8. Visser BC, Ma Y, Zak Y, et al. Failure to comply with NCCN guidelines for the management of pancreatic cancer compromises outcomes. *HPB (Oxford)* 2012;14:539-547. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22762402>.
9. Hoos WA, James PM, Rahib L, et al. Pancreatic cancer clinical trials and accrual in the United States. *J Clin Oncol* 2013;31:3432-3438. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23960185>.
10. U.S. National Library of Medicine-Key MEDLINE® Indicators. Available at: http://www.nlm.nih.gov/bsd/bsd_key.html. Accessed July 24, 2014.
11. Anderson MA, Zolotarevsky E, Cooper KL, et al. Alcohol and tobacco lower the age of presentation in sporadic pancreatic cancer in a dose-dependent manner: a multicenter study. *Am J Gastroenterol* 2012;107:1730-1739. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22929760>.
12. Bosetti C, Lucenteforte E, Silverman DT, et al. Cigarette smoking and pancreatic cancer: an analysis from the International Pancreatic Cancer Case-Control Consortium (Panc4). *Ann Oncol* 2012;23:1880-1888. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22104574>.
13. Hassan MM, Bondy ML, Wolff RA, et al. Risk factors for pancreatic cancer: case-control study. *Am J Gastroenterol* 2007;102:2696-2707. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17764494>.
14. Lynch SM, Vrieling A, Lubin JH, et al. Cigarette smoking and pancreatic cancer: a pooled analysis from the pancreatic cancer cohort consortium. *Am J Epidemiol* 2009;170:403-413. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19561064>.
15. Raimondi S, Maisonneuve P, Lowenfels AB. Epidemiology of pancreatic cancer: an overview. *Nat Rev Gastroenterol Hepatol* 2009;6:699-708. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19806144>.
16. Vrieling A, Bueno-de-Mesquita HB, Boshuizen HC, et al. Cigarette smoking, environmental tobacco smoke exposure and pancreatic

cancer risk in the European Prospective Investigation into Cancer and Nutrition. *Int J Cancer* 2010;126:2394-2403. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19790196>.

17. Mancuso TF, el-Attar AA. Cohort study of workers exposed to betanaphthylamine and benzidine. *J Occup Med* 1967;9:277-285. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6026374>.

18. Antwi SO, Eckert EC, Sabaque CV, et al. Exposure to environmental chemicals and heavy metals, and risk of pancreatic cancer. *Cancer Causes Control* 2015;26:1583-1591. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26293241>.

19. Alsamarrai A, Das SL, Windsor JA, Petrov MS. Factors that affect risk for pancreatic disease in the general population: a systematic review and meta-analysis of prospective cohort studies. *Clin Gastroenterol Hepatol* 2014;12:1635-1644 e1635. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24509242>.

20. Lucenteforte E, La Vecchia C, Silverman D, et al. Alcohol consumption and pancreatic cancer: a pooled analysis in the International Pancreatic Cancer Case-Control Consortium (PanC4). *Ann Oncol* 2012;23:374-382. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21536662>.

21. Bagnardi V, Rota M, Botteri E, et al. Alcohol consumption and site-specific cancer risk: a comprehensive dose-response meta-analysis. *Br J Cancer* 2015;112:580-593. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25422909>.

22. Larsson SC, Orsini N, Wolk A. Body mass index and pancreatic cancer risk: A meta-analysis of prospective studies. *Int J Cancer* 2007;120:1993-1998. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17266034>.

23. Li D, Morris JS, Liu J, et al. Body mass index and risk, age of onset, and survival in patients with pancreatic cancer. *JAMA* 2009;301:2553-2562. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19549972>.

24. Patel AV, Rodriguez C, Bernstein L, et al. Obesity, recreational physical activity, and risk of pancreatic cancer in a large U.S. Cohort. *Cancer Epidemiol Biomarkers Prev* 2005;14:459-466. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15734973>.

25. Genkinger JM, Kitahara CM, Bernstein L, et al. Central adiposity, obesity during early adulthood, and pancreatic cancer mortality in a pooled analysis of cohort studies. *Ann Oncol* 2015;26:2257-2266. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/26347100>.

26. Behrens G, Jochem C, Schmid D, et al. Physical activity and risk of pancreatic cancer: a systematic review and meta-analysis. *Eur J Epidemiol* 2015;30:279-298. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25773752>.

27. Larsson SC, Wolk A. Red and processed meat consumption and risk of pancreatic cancer: meta-analysis of prospective studies. *Br J Cancer* 2012;106:603-607. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22240790>.

28. Thiebaut AC, Jiao L, Silverman DT, et al. Dietary fatty acids and pancreatic cancer in the NIH-AARP diet and health study. *J Natl Cancer Inst* 2009;101:1001-1011. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19561318>.

29. Genkinger JM, Wang M, Li R, et al. Dairy products and pancreatic cancer risk: a pooled analysis of 14 cohort studies. *Ann Oncol* 2014;25:1106-1115. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24631943>.

30. Rohrmann S, Linseisen J, Nothlings U, et al. Meat and fish consumption and risk of pancreatic cancer: results from the European Prospective Investigation into Cancer and Nutrition. *Int J Cancer* 2013;132:617-624. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22610753>.

31. Chen K, Zhang Q, Peng M, et al. Relationship between tea consumption and pancreatic cancer risk: a meta-analysis based on



prospective cohort studies and case-control studies. *Eur J Cancer Prev* 2014;23:353-360. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/24858717>.

32. Zeng JL, Li ZH, Wang ZC, Zhang HL. Green tea consumption and risk of pancreatic cancer: a meta-analysis. *Nutrients* 2014;6:4640-4650. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25353660>.

33. Wolpin BM, Ng K, Bao Y, et al. Plasma 25-hydroxyvitamin D and risk of pancreatic cancer. *Cancer Epidemiol Biomarkers Prev* 2012;21:82-91. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22086883>.

34. Waterhouse M, Risch HA, Bosetti C, et al. Vitamin D and pancreatic cancer: a pooled analysis from the Pancreatic Cancer Case-Control Consortium. *Ann Oncol* 2015;26:1776-1783. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25977560>.

35. Duell EJ, Lucenteforte E, Olson SH, et al. Pancreatitis and pancreatic cancer risk: a pooled analysis in the International Pancreatic Cancer Case-Control Consortium (PanC4). *Ann Oncol* 2012;23:2964-2970. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22767586>.

36. Lowenfels AB, Maisonneuve P, Cavallini G, et al. Pancreatitis and the risk of pancreatic cancer. International Pancreatitis Study Group. *N Engl J Med* 1993;328:1433-1437. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8479461>.

37. Malka D, Hammel P, Maire F, et al. Risk of pancreatic adenocarcinoma in chronic pancreatitis. *Gut* 2002;51:849-852. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12427788>.

38. Munigala S, Kanwal F, Xian H, et al. Increased risk of pancreatic adenocarcinoma after acute pancreatitis. *Clin Gastroenterol Hepatol* 2014;12:1143-1150 e1141. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24440214>.

39. Bracci PM, Wang F, Hassan MM, et al. Pancreatitis and pancreatic cancer in two large pooled case-control studies. *Cancer Causes Control* 2009;20:1723-1731. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19760029>.

40. Majumder S, Bockorny B, Baker WL, Dasanu CA. Association between HBsAg positivity and pancreatic cancer: a meta-analysis. *J Gastrointest Cancer* 2014;45:347-352. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24788082>.

41. Chari ST, Leibson CL, Rabe KG, et al. Probability of pancreatic cancer following diabetes: a population-based study. *Gastroenterology* 2005;129:504-511. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16083707>.

42. Huang Y, Cai X, Qiu M, et al. Prediabetes and the risk of cancer: a meta-analysis. *Diabetologia* 2014;57:2261-2269. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25208757>.

43. Liao WC, Tu YK, Wu MS, et al. Blood glucose concentration and risk of pancreatic cancer: systematic review and dose-response meta-analysis. *Bmj* 2015;349:g7371. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25556126>.

44. Gullo L, Pezzilli R, Morselli-Labate AM. Diabetes and the risk of pancreatic cancer. Italian Pancreatic Cancer Study Group. *N Engl J Med* 1994;331:81-84. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8208269>.

45. Gupta S, Vittinghoff E, Bertenthal D, et al. New-onset diabetes and pancreatic cancer. *Clin Gastroenterol Hepatol* 2006;4:1366-1372; quiz 1301. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16945591>.

46. Raghavan SR, Ballehaninna UK, Chamberlain RS. The impact of perioperative blood glucose levels on pancreatic cancer prognosis and surgical outcomes: an evidence-based review. *Pancreas* 2013;42:1210-1217. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24152946>.



47. Rosa JA, Van Linda BM, Abourizk NN. New-onset diabetes mellitus as a harbinger of pancreatic carcinoma. A case report and literature review. *J Clin Gastroenterol* 1989;11:211-215. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/2661661>.
48. Lee JH, Kim SA, Park HY, et al. New-onset diabetes patients need pancreatic cancer screening? *J Clin Gastroenterol* 2012;46:e58-61. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22138846>.
49. Sah RP, Nagpal SJ, Mukhopadhyay D, Chari ST. New insights into pancreatic cancer-induced paraneoplastic diabetes. *Nat Rev Gastroenterol Hepatol* 2013;10:423-433. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23528347>.
50. Elena JW, Steplowski E, Yu K, et al. Diabetes and risk of pancreatic cancer: a pooled analysis from the pancreatic cancer cohort consortium. *Cancer Causes Control* 2013;24:13-25. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23112111>.
51. Pezzilli R, Casadei R, Morselli-Labate AM. Is type 2 diabetes a risk factor for pancreatic cancer? *JOP* 2009;10:705-706. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19890202>.
52. Bosetti C, Rosato V, Li D, et al. Diabetes, antidiabetic medications, and pancreatic cancer risk: an analysis from the International Pancreatic Cancer Case-Control Consortium. *Ann Oncol* 2014;25:2065-2072. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25057164>.
53. Bodmer M, Becker C, Meier C, et al. Use of antidiabetic agents and the risk of pancreatic cancer: a case-control analysis. *Am J Gastroenterol* 2012;107:620-626. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22290402>.
54. Li D, Yeung S-CJ, Hassan MM, et al. Antidiabetic therapies affect risk of pancreatic cancer. *Gastroenterology* 2009;137:482-488. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19375425>.
55. Singh S, Singh PP, Singh AG, et al. Anti-diabetic medications and risk of pancreatic cancer in patients with diabetes mellitus: a systematic review and meta-analysis. *Am J Gastroenterol* 2013;108:510-519; quiz 520. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23399556>.
56. Franciosi M, Lucisano G, Lapice E, et al. Metformin therapy and risk of cancer in patients with type 2 diabetes: systematic review. *PLoS One* 2013;8:e71583. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23936520>.
57. Soranna D, Scotti L, Zambon A, et al. Cancer risk associated with use of metformin and sulfonylurea in type 2 diabetes: a meta-analysis. *Oncologist* 2012;17:813-822. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22643536>.
58. Wang Z, Lai ST, Xie L, et al. Metformin is associated with reduced risk of pancreatic cancer in patients with type 2 diabetes mellitus: A systematic review and meta-analysis. *Diabetes Res Clin Pract* 2014;106:19-26. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24837144>.
59. Chaiteerakij R, Petersen GM, Bamlet WR, et al. Metformin use and survival of patients with pancreatic cancer: a cautionary lesson. *J Clin Oncol* 2016;34:1898-1904. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/27069086>.
60. Sadeghi N, Abbruzzese JL, Yeung SC, et al. Metformin use is associated with better survival of diabetic patients with pancreatic cancer. *Clin Cancer Res* 2012;18:2905-2912. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22465831>.
61. Toriola AT, Stolzenberg-Solomon R, Dalidowicz L, et al. Diabetes and pancreatic cancer survival: a prospective cohort-based study. *Br J Cancer* 2014;111:181-185. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24786605>.



62. Hruban RH, Canto MI, Goggins M, et al. Update on familial pancreatic cancer. *Adv Surg* 2010;44:293-311. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20919528>.

63. Humphris JL, Johns AL, Simpson SH, et al. Clinical and pathologic features of familial pancreatic cancer. *Cancer* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25313458>.

64. Lynch HT, Smyrk T, Kern SE, et al. Familial pancreatic cancer: a review. *Semin Oncol* 1996;23:251-275. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8623061>.

65. Wang W, Chen S, Brune KA, et al. PancPRO: risk assessment for individuals with a family history of pancreatic cancer. *J Clin Oncol* 2007;25:1417-1422. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17416862>.

66. Klein AP, Brune KA, Petersen GM, et al. Prospective risk of pancreatic cancer in familial pancreatic cancer kindreds. *Cancer Res* 2004;64:2634-2638. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15059921>.

67. Hemminki A, Markie D, Tomlinson I, et al. A serine/threonine kinase gene defective in Peutz-Jeghers syndrome. *Nature* 1998;391:184-187. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9428765>.

68. Jenne DE, Reimann H, Nezu J, et al. Peutz-Jeghers syndrome is caused by mutations in a novel serine threonine kinase. *Nat Genet* 1998;18:38-43. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9425897>.

69. Korsse SE, Harinck F, van Lier MG, et al. Pancreatic cancer risk in Peutz-Jeghers syndrome patients: a large cohort study and implications for surveillance. *J Med Genet* 2013;50:59-64. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23240097>.

70. Giardiello FM, Brensinger JD, Tersmette AC, et al. Very high risk of cancer in familial Peutz-Jeghers syndrome. *Gastroenterology*

2000;119:1447-1453. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11113065>.

71. van Lier MG, Wagner A, Mathus-Vliegen EM, et al. High cancer risk in Peutz-Jeghers syndrome: a systematic review and surveillance recommendations. *Am J Gastroenterol* 2010;105:1258-1264; author reply 1265. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20051941>.

72. Su GH, Hruban RH, Bansal RK, et al. Germline and somatic mutations of the STK11/LKB1 Peutz-Jeghers gene in pancreatic and biliary cancers. *Am J Pathol* 1999;154:1835-1840. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10362809>.

73. Weiss FU. Pancreatic cancer risk in hereditary pancreatitis. *Front Physiol* 2014;5:70. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24600409>.

74. LaRusch J, Solomon S, Whitcomb DC. Pancreatitis Overview. In: Pagon RA, Adam MP, Ardinger HH, et al., eds. *GeneReviews*(R). Seattle (WA): University of Washington, Seattle; 2014.

75. Howes N, Lerch MM, Greenhalf W, et al. Clinical and genetic characteristics of hereditary pancreatitis in Europe. *Clin Gastroenterol Hepatol* 2004;2:252-261. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15017610>.

76. Lowenfels AB, Maisonneuve P, DiMagno EP, et al. Hereditary pancreatitis and the risk of pancreatic cancer. International Hereditary Pancreatitis Study Group. *J Natl Cancer Inst* 1997;89:442-446. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9091646>.

77. Rebours V, Levy P, Ruzsiewicz P. An overview of hereditary pancreatitis. *Dig Liver Dis* 2012;44:8-15. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21907651>.

78. Whelan AJ, Bartsch D, Goodfellow PJ. Brief report: a familial syndrome of pancreatic cancer and melanoma with a mutation in the



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CDKN2 tumor-suppressor gene. N Engl J Med 1995;333:975-977. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7666917>.

79. de Snoo FA, Bishop DT, Bergman W, et al. Increased risk of cancer other than melanoma in CDKN2A founder mutation (p16-Leiden)-positive melanoma families. Clin Cancer Res 2008;14:7151-7157. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18981015>.

80. Vasen HF, Gruis NA, Frants RR, et al. Risk of developing pancreatic cancer in families with familial atypical multiple mole melanoma associated with a specific 19 deletion of p16 (p16-Leiden). Int J Cancer 2000;87:809-811. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10956390>.

81. Lynch HT, Brand RE, Hogg D, et al. Phenotypic variation in eight extended CDKN2A germline mutation familial atypical multiple mole melanoma-pancreatic carcinoma-prone families: the familial atypical mole melanoma-pancreatic carcinoma syndrome. Cancer 2002;94:84-96. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11815963>.

82. Zhen DB, Rabe KG, Gallinger S, et al. BRCA1, BRCA2, PALB2, and CDKN2A mutations in familial pancreatic cancer: a PACGENE study. Genet Med 2015;17:569-577. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25356972>.

83. Vasen H, Ibrahim I, Ponce CG, et al. Benefit of Surveillance for Pancreatic Cancer in High-Risk Individuals: Outcome of Long-Term Prospective Follow-Up Studies From Three European Expert Centers. J Clin Oncol 2016;34:2010-2019. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/27114589>.

84. Ghiorzo P, Fornarini G, Sciallero S, et al. CDKN2A is the main susceptibility gene in Italian pancreatic cancer families. J Med Genet 2012;49:164-170. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22368299>.

85. Aaltonen LA, Salovaara R, Kristo P, et al. Incidence of hereditary nonpolyposis colorectal cancer and the feasibility of molecular

screening for the disease. N Engl J Med 1998;338:1481-1487. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9593786>.

86. Lindor NM, Petersen GM, Spurdle AB, et al. Pancreatic cancer and a novel MSH2 germline alteration. Pancreas 2011;40:1138-1140. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21926548>.

87. Lynch HT, de la Chapelle A. Hereditary colorectal cancer. N Engl J Med 2003;348:919-932. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12621137>.

88. Hampel H, Frankel WL, Martin E, et al. Screening for the Lynch syndrome (hereditary nonpolyposis colorectal cancer). N Engl J Med 2005;352:1851-1860. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15872200>.

89. Hampel H, Frankel WL, Martin E, et al. Feasibility of screening for Lynch syndrome among patients with colorectal cancer. J Clin Oncol 2008;26:5783-5788. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18809606>.

90. Boland CR, Goel A. Microsatellite instability in colorectal cancer. Gastroenterology 2010;138:2073-2087 e2073. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20420947>.

91. Kastrinos F, Mukherjee B, Tayob N, et al. Risk of pancreatic cancer in families with Lynch syndrome. Jama 2009;302:1790-1795. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19861671>.

92. Win AK, Young JP, Lindor NM, et al. Colorectal and other cancer risks for carriers and noncarriers from families with a DNA mismatch repair gene mutation: a prospective cohort study. J Clin Oncol 2012;30:958-964. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22331944>.

93. Hu C, Hart SN, Bamlet WR, et al. Prevalence of pathogenic mutations in cancer predisposition genes among pancreatic cancer



patients. *Cancer Epidemiol Biomarkers Prev* 2016;25:207-211.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26483394>.

94. Cancer risks in BRCA2 mutation carriers. *J Natl Cancer Inst* 1999;91:1310-1316. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/10433620>.

95. Al-Sukhni W, Rothenmund H, Borgida AE, et al. Germline BRCA1 mutations predispose to pancreatic adenocarcinoma. *Hum Genet* 2008;124:271-278. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18762988>.

96. Ferrone CR, Levine DA, Tang LH, et al. BRCA germline mutations in Jewish patients with pancreatic adenocarcinoma. *J Clin Oncol* 2009;27:433-438. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/19064968>.

97. Hahn SA, Greenhalf B, Ellis I, et al. BRCA2 germline mutations in familial pancreatic carcinoma. *J Natl Cancer Inst* 2003;95:214-221.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12569143>.

98. Iqbal J, Ragone A, Lubinski J, et al. The incidence of pancreatic cancer in BRCA1 and BRCA2 mutation carriers. *Br J Cancer* 2012;107:2005-2009. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23099806>.

99. van Asperen CJ, Brohet RM, Meijers-Heijboer EJ, et al. Cancer risks in BRCA2 families: estimates for sites other than breast and ovary. *J Med Genet* 2005;42:711-719. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/16141007>.

100. Liede A, Karlan BY, Narod SA. Cancer risks for male carriers of germline mutations in BRCA1 or BRCA2: a review of the literature. *J Clin Oncol* 2004;22:735-742. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/14966099>.

101. Holter S, Borgida A, Dodd A, et al. Germline BRCA mutations in a large clinic-based cohort of patients with pancreatic adenocarcinoma. *J*

Clin Oncol 2015. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/25940717>.

102. Lucas AL, Frado LE, Hwang C, et al. BRCA1 and BRCA2 germline mutations are frequently demonstrated in both high-risk pancreatic cancer screening and pancreatic cancer cohorts. *Cancer* 2014;120:1960-1967. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24737347>.

103. Salo-Mullen EE, O'Reilly EM, Kelsen DP, et al. Identification of germline genetic mutations in patients with pancreatic cancer. *Cancer* 2015;121:4382-4388. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/26440929>.

104. Couch FJ, Johnson MR, Rabe K, et al. Germ line Fanconi anemia complementation group C mutations and pancreatic cancer. *Cancer Res* 2005;65:383-386. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15695377>.

105. Slater EP, Langer P, Niemczyk E, et al. PALB2 mutations in European familial pancreatic cancer families. *Clin Genet* 2010;78:490-494. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20412113>.

106. van der Heijden MS, Yeo CJ, Hruban RH, Kern SE. Fanconi anemia gene mutations in young-onset pancreatic cancer. *Cancer Res* 2003;63:2585-2588. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/12750283>.

107. Roberts NJ, Jiao Y, Yu J, et al. ATM mutations in patients with hereditary pancreatic cancer. *Cancer Discov* 2012;2:41-46. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22585167>.

108. Syngal S, Brand RE, Church JM, et al. ACG clinical guideline: Genetic testing and management of hereditary gastrointestinal cancer syndromes. *Am J Gastroenterol* 2015;110:223-262; quiz 263. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25645574>.



109. Clores MJ, Thosani A, Buscaglia JM. Multidisciplinary diagnostic and therapeutic approaches to pancreatic cystic lesions. *J Multidiscip Healthc* 2014;7:81-91. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24520195>.

110. Farrell JJ, Fernandez-del Castillo C. Pancreatic cystic neoplasms: management and unanswered questions. *Gastroenterology* 2013;144:1303-1315. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23622140>.

111. Law JK, Hruban RH, Lennon AM. Management of pancreatic cysts: a multidisciplinary approach. *Curr Opin Gastroenterol* 2013;29:509-516. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23872487>.

112. Tanaka M, Fernandez-del Castillo C, Adsay V, et al. International consensus guidelines 2012 for the management of IPMN and MCN of the pancreas. *Pancreatology* 2012;12:183-197. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22687371>.

113. Del Chiaro M, Verbeke C, Salvia R, et al. European experts consensus statement on cystic tumours of the pancreas. *Dig Liver Dis* 2013;45:703-711. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23415799>.

114. Canto MI, Goggins M, Hruban RH, et al. Screening for early pancreatic neoplasia in high-risk individuals: a prospective controlled study. *Clin Gastroenterol Hepatol* 2006;4:766-781; quiz 665. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16682259>.

115. Canto MI, Hruban RH, Fishman EK, et al. Frequent detection of pancreatic lesions in asymptomatic high-risk individuals. *Gastroenterology* 2012;142:796-804; quiz e714-795. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22245846>.

116. Al-Sukhni W, Borgida A, Rothenmund H, et al. Screening for pancreatic cancer in a high-risk cohort: an eight-year experience. *J*

Gastrointest Surg 2012;16:771-783. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22127781>.

117. Poley JW, Kluijft I, Gouma DJ, et al. The yield of first-time endoscopic ultrasonography in screening individuals at a high risk of developing pancreatic cancer. *Am J Gastroenterol* 2009;104:2175-2181. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19491823>.

118. Langer P, Kann PH, Fendrich V, et al. Five years of prospective screening of high-risk individuals from families with familial pancreatic cancer. *Gut* 2009;58:1410-1418. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19470496>.

119. Ding Z, Wu H, Zhang J, et al. MicroRNAs as novel biomarkers for pancreatic cancer diagnosis: a meta-analysis based on 18 articles. *Tumour Biol* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24880590>.

120. Kobayashi T, Nishiumi S, Ikeda A, et al. A novel serum metabolomics-based diagnostic approach to pancreatic cancer. *Cancer Epidemiol Biomarkers Prev* 2013;22:571-579. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23542803>.

121. Mayers JR, Wu C, Clish CB, et al. Elevation of circulating branched-chain amino acids is an early event in human pancreatic adenocarcinoma development. *Nat Med* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25261994>.

122. Schultz NA, Dehlendorff C, Jensen BV, et al. MicroRNA biomarkers in whole blood for detection of pancreatic cancer. *Jama* 2014;311:392-404. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24449318>.

123. Liggett T, Melnikov A, Yi QL, et al. Differential methylation of cell-free circulating DNA among patients with pancreatic cancer versus chronic pancreatitis. *Cancer* 2010;116:1674-1680. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20143430>.

124. O'Brien DP, Sandanayake NS, Jenkinson C, et al. Serum CA19-9 is significantly up-regulated up to 2 years prior to diagnosis with pancreatic cancer: implications for early disease detection. *Clin Cancer Res* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24938522>.

125. Canto MI, Harinck F, Hruban RH, et al. International Cancer of the Pancreas Screening (CAPS) Consortium summit on the management of patients with increased risk for familial pancreatic cancer. *Gut* 2013;62:339-347. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23135763>.

126. Callery MP, Chang KJ, Fishman EK, et al. Pretreatment assessment of resectable and borderline resectable pancreatic cancer: expert consensus statement. *Ann Surg Oncol* 2009;16:1727-1733. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19396496>.

127. Al-Hawary MM, Francis IR, Chari ST, et al. Pancreatic ductal adenocarcinoma radiology reporting template: consensus statement of the society of abdominal radiology and the american pancreatic association. *Gastroenterology* 2014;146:291-304.e291. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24355035>.

128. Edge SB, Byrd DR, Compton CC, et al., eds. *AJCC Cancer Staging Manual* (ed 7th). New York: Springer; 2010.

129. Bilimoria KY, Bentrem DJ, Ko CY, et al. Validation of the 6th edition AJCC Pancreatic Cancer Staging System: report from the National Cancer Database. *Cancer* 2007;110:738-744. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17580363>.

130. Wong JC, Lu DSK. Staging of pancreatic adenocarcinoma by imaging studies. *Clin Gastroenterol Hepatol* 2008;6:1301-1308. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18948228>.

131. Fuhrman GM, Charnsangavej C, Abbruzzese JL, et al. Thin-section contrast-enhanced computed tomography accurately predicts the resectability of malignant pancreatic neoplasms. *Am J Surg*

1994;167:104-111. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7906097>.

132. Horton KM, Fishman EK. Adenocarcinoma of the pancreas: CT imaging. *Radiol Clin North Am* 2002;40:1263-1272. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12479710>.

133. House MG, Yeo CJ, Cameron JL, et al. Predicting resectability of periampullary cancer with three-dimensional computed tomography. *J Gastrointest Surg* 2004;8:280-288. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15019924>.

134. Klauss M, Schobinger M, Wolf I, et al. Value of three-dimensional reconstructions in pancreatic carcinoma using multidetector CT: initial results. *World J Gastroenterol* 2009;15:5827-5832. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19998504>.

135. McNulty NJ, Francis IR, Platt JF, et al. Multi--detector row helical CT of the pancreas: effect of contrast-enhanced multiphasic imaging on enhancement of the pancreas, peripancreatic vasculature, and pancreatic adenocarcinoma. *Radiology* 2001;220:97-9102. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11425979>.

136. Walters DM, Lapar DJ, de Lange EE, et al. Pancreas-protocol imaging at a high-volume center leads to improved preoperative staging of pancreatic ductal adenocarcinoma. *Ann Surg Oncol* 2011;18:2764-2771. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21484522>.

137. Schima W, Ba-Ssalamah A, Goetzinger P, et al. State-of-the-art magnetic resonance imaging of pancreatic cancer. *Top Magn Reson Imaging* 2007;18:421-429. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18303400>.

138. Vachiranubhap B, Kim YH, Balci NC, Semelka RC. Magnetic resonance imaging of adenocarcinoma of the pancreas. *Top Magn Reson Imaging* 2009;20:3-9. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19687720>.

139. Li JH, He R, Li YM, et al. Endoscopic ultrasonography for tumor node staging and vascular invasion in pancreatic cancer: a meta-analysis. *Dig Surg* 2014;31:297-305. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25376486>.

140. Agarwal B, Abu-Hamda E, Molke KL, et al. Endoscopic ultrasound-guided fine needle aspiration and multidetector spiral CT in the diagnosis of pancreatic cancer. *Am J Gastroenterol* 2004;99:844-850. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15128348>.

141. Deerenberg EB, Poley JW, Hermans JJ, et al. Role of endoscopic ultrasonography in patients suspected of pancreatic cancer with negative helical MDCT scan. *Dig Surg* 2011;28:398-403. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22188923>.

142. Nawaz H, Fan CY, Kloke J, et al. Performance characteristics of endoscopic ultrasound in the staging of pancreatic cancer: a meta-analysis. *JOP* 2013;14:484-497. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24018593>.

143. Wang W, Shpaner A, Krishna SG, et al. Use of EUS-FNA in diagnosing pancreatic neoplasm without a definitive mass on CT. *Gastrointest Endosc* 2013;78:73-80. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23523302>.

144. Rosch T, Braig C, Gain T, et al. Staging of pancreatic and ampullary carcinoma by endoscopic ultrasonography. Comparison with conventional sonography, computed tomography, and angiography. *Gastroenterology* 1992;102:188-199. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/1727753>.

145. Varadarajulu S, Wallace MB. Applications of endoscopic ultrasonography in pancreatic cancer. *Cancer Control* 2004;11:15-22. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14749619>.

146. Buchs NC, Chilcott M, Poletti PA, et al. Vascular invasion in pancreatic cancer: Imaging modalities, preoperative diagnosis and

surgical management. *World J Gastroenterol* 2010;16:818-831. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20143460>.

147. Inoue K, Ohuchida J, Ohtsuka T, et al. Severe localized stenosis and marked dilatation of the main pancreatic duct are indicators of pancreatic cancer instead of chronic pancreatitis on endoscopic retrograde balloon pancreatography. *Gastrointest Endosc* 2003;58:510-515. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14520282>.

148. Nallamothe G, Hilden K, Adler DG. Endoscopic retrograde cholangiopancreatography for non-gastroenterologists: what you need to know. *Hosp Pract (Minneap)* 2011;39:70-80. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21576899>.

149. Pavey DA, Gress FG. The role of EUS-guided FNA for the evaluation of biliary strictures. *Gastrointest Endosc* 2006;64:334-337. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16923478>.

150. Tirkes T, Sandrasegaran K, Sanyal R, et al. Secretin-enhanced MR cholangiopancreatography: spectrum of findings. *Radiographics* 2013;33:1889-1906. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24224585>.

151. Farma JM, Santillan AA, Melis M, et al. PET/CT fusion scan enhances CT staging in patients with pancreatic neoplasms. *Ann Surg Oncol* 2008;15:2465-2471. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18551347>.

152. Rijkers AP, Valkema R, Duivenvoorden HJ, van Eijck CH. Usefulness of F-18-fluorodeoxyglucose positron emission tomography to confirm suspected pancreatic cancer: a meta-analysis. *Eur J Surg Oncol* 2014;40:794-804. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24755095>.

153. Wang Z, Chen JQ, Liu JL, et al. FDG-PET in diagnosis, staging and prognosis of pancreatic carcinoma: a meta-analysis. *World J Gastroenterol* 2013;19:4808-4817. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23922481>.



NCCN Guidelines Version 2.2016 Pancreatic Adenocarcinoma

154. Ahmed SI, Bochkarev V, Oleynikov D, Sasson AR. Patients with pancreatic adenocarcinoma benefit from staging laparoscopy. *J Laparoendosc Adv Surg Tech A* 2006;16:458-463. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17004868>.

155. Allen VB, Gurusamy KS, Takwoingi Y, et al. Diagnostic accuracy of laparoscopy following computed tomography (CT) scanning for assessing the resectability with curative intent in pancreatic and periampullary cancer. *Cochrane Database Syst Rev* 2013;11:Cd009323. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24272022>.

156. Warshaw AL, Gu ZY, Wittenberg J, Waltman AC. Preoperative staging and assessment of resectability of pancreatic cancer. *Arch Surg* 1990;125:230-233. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/2154172>.

157. Andersson R, Vagianos CE, Williamson RCN. Preoperative staging and evaluation of resectability in pancreatic ductal adenocarcinoma. *HPB (Oxford)* 2004;6:5-12. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18333037>.

158. Alexakis N, Gomatos IP, Sbarounis S, et al. High serum CA 19-9 but not tumor size should select patients for staging laparoscopy in radiological resectable pancreas head and peri-ampullary cancer. *Eur J Surg Oncol* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25266999>.

159. Karachristos A, Scarmeas N, Hoffman JP. CA 19-9 levels predict results of staging laparoscopy in pancreatic cancer. *J Gastrointest Surg* 2005;9:1286-1292. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16332484>.

160. White R, Winston C, Gonen M, et al. Current utility of staging laparoscopy for pancreatic and peripancreatic neoplasms. *J Am Coll Surg* 2008;206:445-450. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18308214>.

161. Ferrone CR, Haas B, Tang L, et al. The influence of positive peritoneal cytology on survival in patients with pancreatic adenocarcinoma. *J Gastrointest Surg* 2006;10:1347-1353. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17175453>.

162. Brugge WR, De Witt J, Klapman JB, et al. Techniques for cytologic sampling of pancreatic and bile duct lesions: The Papanicolaou Society of Cytopathology Guidelines. *Cytojournal* 2014;11:2. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25191516>.

163. Micames C, Jowell PS, White R, et al. Lower frequency of peritoneal carcinomatosis in patients with pancreatic cancer diagnosed by EUS-guided FNA vs. percutaneous FNA. *Gastrointest Endosc* 2003;58:690-695. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14595302>.

164. Okasha HH, Naga MI, Esmat S, et al. Endoscopic ultrasound-guided fine needle aspiration versus percutaneous ultrasound-guided fine needle aspiration in diagnosis of focal pancreatic masses. *Endosc Ultrasound* 2013;2:190-193. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24949394>.

165. Layfield LJ, Dodd L, Factor R, Schmidt RL. Malignancy risk associated with diagnostic categories defined by the Papanicolaou Society of Cytopathology pancreaticobiliary guidelines. *Cancer Cytopathol* 2014;122:420-427. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24339321>.

166. Chen YK, Pleskow DK. SpyGlass single-operator peroral cholangiopancreatography system for the diagnosis and therapy of bile-duct disorders: a clinical feasibility study (with video). *Gastrointest Endosc* 2007;65:832-841. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17466202>.

167. Strasberg SM, Middleton WD, Teefey SA, et al. Management of diagnostic dilemmas of the pancreas by ultrasonographically guided laparoscopic biopsy. *Surgery* 1999;126:736-741; discussion 741-733. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10520923>.

168. Catalogue of Somatic Mutations in Cancer (COSMIC). Hinxton, UK: Wellcome Trust Sanger Institute; Available at: <http://cancer.sanger.ac.uk/cosmic>. Accessed March 10, 2016.

169. Waddell N, Pajic M, Patch AM, et al. Whole genomes redefine the mutational landscape of pancreatic cancer. *Nature* 2015;518:495-501. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25719666>.

170. Zagouri F, Sergentanis TN, Chrysikos D, et al. Molecularly targeted therapies in metastatic pancreatic cancer: a systematic review. *Pancreas* 2013;42:760-773. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/23774698>.

171. Hu H, Zhang Q, Huang C, et al. Diagnostic value of S100P for pancreatic cancer: a meta-analysis. *Tumour Biol* 2014;35:9479-9485. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25123266>.

172. Safi F, Roscher R, Bittner R, et al. High sensitivity and specificity of CA 19-9 for pancreatic carcinoma in comparison to chronic pancreatitis. Serological and immunohistochemical findings. *Pancreas* 1987;2:398-403. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/3306667>.

173. Morris-Stiff G, Taylor MA. Ca19-9 and pancreatic cancer: Is it really that good? *J Gastrointest Oncol* 2012;3:88-89. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22811875>.

174. Huang Z, Liu F. Diagnostic value of serum carbohydrate antigen 19-9 in pancreatic cancer: a meta-analysis. *Tumour Biol* 2014;35:7459-7465. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/24789274>.

175. Ballehaninna UK, Chamberlain RS. The clinical utility of serum CA 19-9 in the diagnosis, prognosis and management of pancreatic adenocarcinoma: An evidence based appraisal. *J Gastrointest Oncol* 2012;3:105-119. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22811878>.

176. Hartwig W, Strobel O, Hinz U, et al. CA19-9 in potentially resectable pancreatic cancer: perspective to adjust surgical and

perioperative therapy. *Ann Surg Oncol* 2013;20:2188-2196. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23247983>.

177. Kim YC, Kim HJ, Park JH, et al. Can preoperative CA19-9 and CEA levels predict the resectability of patients with pancreatic adenocarcinoma? *J Gastroenterol Hepatol* 2009;24:1869-1875. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19686409>.

178. Kondo N, Murakami Y, Uemura K, et al. Prognostic impact of perioperative serum CA 19-9 levels in patients with resectable pancreatic cancer. *Ann Surg Oncol* 2010;17:2321-2329. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20336387>.

179. Bauer TM, El-Rayes BF, Li X, et al. Carbohydrate antigen 19-9 is a prognostic and predictive biomarker in patients with advanced pancreatic cancer who receive gemcitabine-containing chemotherapy: a pooled analysis of 6 prospective trials. *Cancer* 2013;119:285-292. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22786786>.

180. Berger AC, Garcia M, Hoffman JP, et al. Postresection CA 19-9 predicts overall survival in patients with pancreatic cancer treated with adjuvant chemoradiation: a prospective validation by RTOG 9704. *J Clin Oncol* 2008;26:5918-5922. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19029412>.

181. Berger AC, Winter K, Hoffman JP, et al. Five year results of US intergroup/RTOG 9704 with postoperative CA 19-9 \leq 90 U/mL and comparison to the CONKO-001 trial. *Int J Radiat Oncol Biol Phys* 2012;84:e291-297. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22682806>.

182. Ferrone CR, Finkelstein DM, Thayer SP, et al. Perioperative CA19-9 levels can predict stage and survival in patients with resectable pancreatic adenocarcinoma. *J Clin Oncol* 2006;24:2897-2902. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16782929>.

183. Humphris JL, Chang DK, Johns AL, et al. The prognostic and predictive value of serum CA19.9 in pancreatic cancer. *Ann Oncol*

2012;23:1713-1722. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22241899>.

184. Montgomery RC, Hoffman JP, Riley LB, et al. Prediction of recurrence and survival by post-resection CA 19-9 values in patients with adenocarcinoma of the pancreas. *Ann Surg Oncol* 1997;4:551-556. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/9367020>.

185. Tzeng CW, Balachandran A, Ahmad M, et al. Serum carbohydrate antigen 19-9 represents a marker of response to neoadjuvant therapy in patients with borderline resectable pancreatic cancer. *HPB (Oxford)* 2014;16:430-438. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23991810>.

186. Hess V, Glimelius B, Grawe P, et al. CA 19-9 tumour-marker response to chemotherapy in patients with advanced pancreatic cancer enrolled in a randomised controlled trial. *Lancet Oncol* 2008;9:132-138. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18249033>.

187. Pelzer U, Hilbig A, Sinn M, et al. Value of carbohydrate antigen 19-9 in predicting response and therapy control in patients with metastatic pancreatic cancer undergoing first-line therapy. *Front Oncol* 2013;3:155. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23785668>.

188. Halm U, Schumann T, Schiefke I, et al. Decrease of CA 19-9 during chemotherapy with gemcitabine predicts survival time in patients with advanced pancreatic cancer. *Br J Cancer* 2000;82:1013-1016. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/10737382>.

189. Ishii H, Okada S, Sato T, et al. CA 19-9 in evaluating the response to chemotherapy in advanced pancreatic cancer. *Hepatogastroenterology* 1997;44:279-283. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/9058159>.

<http://www.ncbi.nlm.nih.gov/pubmed/9058159>.

190. Ko AH, Hwang J, Venook AP, et al. Serum CA19-9 response as a surrogate for clinical outcome in patients receiving fixed-dose rate gemcitabine for advanced pancreatic cancer. *Br J Cancer* 2005;93:195-199. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15999098>.

191. Wong D, Ko AH, Hwang J, et al. Serum CA19-9 decline compared to radiographic response as a surrogate for clinical outcomes in patients with metastatic pancreatic cancer receiving chemotherapy. *Pancreas* 2008;37:269-274. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18815548>.

192. Tempero MA, Uchida E, Takasaki H, et al. Relationship of carbohydrate antigen 19-9 and Lewis antigens in pancreatic cancer. *Cancer Res* 1987;47:5501-5503. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/3308077>.

193. Mann DV, Edwards R, Ho S, et al. Elevated tumour marker CA19-9: clinical interpretation and influence of obstructive jaundice. *Eur J Surg Oncol* 2000;26:474-479. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/11016469>.

194. Marrelli D, Caruso S, Pedrazzani C, et al. CA19-9 serum levels in obstructive jaundice: clinical value in benign and malignant conditions. *Am J Surg* 2009;198:333-339. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/19375064>.

195. NIH state-of-the-science statement on endoscopic retrograde cholangiopancreatography (ERCP) for diagnosis and therapy. *NIH Consens State Sci Statements* 2002;19:1-26. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/14768653>.

196. Campisi A, Brancatelli G, Vullierme MP, et al. Are pancreatic calcifications specific for the diagnosis of chronic pancreatitis? A multidetector-row CT analysis. *Clin Radiol* 2009;64:903-911. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/19664481>.

197. Kajiwara M, Kojima M, Konishi M, et al. Autoimmune pancreatitis with multifocal lesions. *J Hepatobiliary Pancreat Surg* 2008;15:449-452. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18670850>.

198. Kalady MF, Peterson B, Baillie J, et al. Pancreatic duct strictures: identifying risk of malignancy. *Ann Surg Oncol* 2004;11:581-588. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15150064>.



199. Menges M, Lerch MM, Zeitz M. The double duct sign in patients with malignant and benign pancreatic lesions. *Gastrointest Endosc* 2000;52:74-77. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/10882966>.

200. Finkelberg DL, Sahani D, Deshpande V, Brugge WR. Autoimmune pancreatitis. *N Engl J Med* 2006;355:2670-2676. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17182992>.

201. Law R, Bronner M, Vogt D, Stevens T. Autoimmune pancreatitis: a mimic of pancreatic cancer. *Cleve Clin J Med* 2009;76:607-615. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/19797461>.

202. Salla C, Chatzipantelis P, Konstantinou P, et al. EUS-FNA contribution in the identification of autoimmune pancreatitis: a case report. *JOP* 2007;8:598-604. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17873466>.

203. Holmes BJ, Hruban RH, Wolfgang CL, Ali SZ. Fine needle aspirate of autoimmune pancreatitis (lymphoplasmacytic sclerosing pancreatitis): cytomorphic characteristics and clinical correlates. *Acta Cytol* 2012;56:228-232. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22555522>.

204. Learn PA, Grossman EB, Do RK, et al. Pitfalls in avoiding operation for autoimmune pancreatitis. *Surgery* 2011;150:968-974. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/21893326>.

205. Hardacre JM, Iacobuzio-Donahue CA, Sohn TA, et al. Results of pancreaticoduodenectomy for lymphoplasmacytic sclerosing pancreatitis. *Ann Surg* 2003;237:853-858; discussion 858-859. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/12796582>.

206. Sah RP, Chari ST. Autoimmune pancreatitis: an update on classification, diagnosis, natural history and management. *Curr Gastroenterol Rep* 2012;14:95-105. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22350841>.

207. Hamano H, Kawa S, Horiuchi A, et al. High serum IgG4 concentrations in patients with sclerosing pancreatitis. *N Engl J Med* 2001;344:732-738. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/11236777>.

208. van Heerde MJ, Buijs J, Hansen BE, et al. Serum level of Ca 19-9 increases ability of IgG4 test to distinguish patients with autoimmune pancreatitis from those with pancreatic carcinoma. *Dig Dis Sci* 2014;59:1322-1329. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24385012>.

209. Burris HA, 3rd, Moore MJ, Andersen J, et al. Improvements in survival and clinical benefit with gemcitabine as first-line therapy for patients with advanced pancreas cancer: a randomized trial. *J Clin Oncol* 1997;15:2403-2413. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/9196156>.

210. Oettle H, Post S, Neuhaus P, et al. Adjuvant chemotherapy with gemcitabine vs observation in patients undergoing curative-intent resection of pancreatic cancer: a randomized controlled trial. *JAMA* 2007;297:267-277. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17227978>.

211. Oettle H, Neuhaus P, Hochhaus A, et al. Adjuvant chemotherapy with gemcitabine and long-term outcomes among patients with resected pancreatic cancer: the CONKO-001 randomized trial. *JAMA* 2013;310:1473-1481. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24104372>.

212. Mackey JR, Mani RS, Selner M, et al. Functional nucleoside transporters are required for gemcitabine influx and manifestation of toxicity in cancer cell lines. *Cancer Res* 1998;58:4349-4357. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/9766663>.

213. Farrell JJ, Elsaleh H, Garcia M, et al. Human equilibrative nucleoside transporter 1 levels predict response to gemcitabine in patients with pancreatic cancer. *Gastroenterology* 2009;136:187-195. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18992248>.

214. Greenhalf W, Ghaneh P, Neoptolemos JP, et al. Pancreatic cancer hENT1 expression and survival from gemcitabine in patients from the ESPAC-3 trial. *J Natl Cancer Inst* 2014;106:djt347. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24301456>.

215. Liu ZQ, Han YC, Zhang X, et al. Prognostic value of human equilibrative nucleoside transporter1 in pancreatic cancer receiving gemcitabine-based chemotherapy: a meta-analysis. *PLoS One* 2014;9:e87103. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24475233>.

216. Marechal R, Bachet JB, Mackey JR, et al. Levels of gemcitabine transport and metabolism proteins predict survival times of patients treated with gemcitabine for pancreatic adenocarcinoma. *Gastroenterology* 2012;143:664-674 e661-666. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22705007>.

217. Saif M, Lee Y, Kim R. Harnessing gemcitabine metabolism: a step towards personalized medicine for pancreatic cancer. *Ther Adv Med Oncol* 2012;4:341-346. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23118809>.

218. Zhu Y, Qi M, Lao L, et al. Human equilibrative nucleoside transporter 1 predicts survival in patients with pancreatic cancer treated with gemcitabine: a meta-analysis. *Genet Test Mol Biomarkers* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24625353>.

219. Ormanns S, Heinemann V, Raponi M, et al. Human equilibrative nucleoside transporter 1 is not predictive for gemcitabine efficacy in advanced pancreatic cancer: translational results from the AIO-PK0104 phase III study with the clone SP120 rabbit antibody. *Eur J Cancer* 2014;50:1891-1899. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24857044>.

220. Sinn M, Sinn BV, Stieler J, et al. Hent1 expression in patients with pancreatic cancer treated with gemcitabine after curative intended resection: Results from the CONKO-001 trial [abstract]. *ASCO Meeting*

Abstracts 2014;32:4124. Available at: http://meeting.ascopubs.org/cgi/content/abstract/32/15_suppl/4124.

221. Poplin E, Wasan H, Rolfe L, et al. Randomized, multicenter, phase II study of CO-101 versus gemcitabine in patients with metastatic pancreatic ductal adenocarcinoma: including a prospective evaluation of the role of hENT1 in gemcitabine or CO-101 sensitivity. *J Clin Oncol* 2013;31:4453-4461. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24220555>.

222. Grunewald R, Abbruzzese JL, Tarassoff P, Plunkett W. Saturation of 2',2'-difluorodeoxycytidine 5'-triphosphate accumulation by mononuclear cells during a phase I trial of gemcitabine. *Cancer Chemother Pharmacol* 1991;27:258-262. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/1998982>.

223. Tempero M, Plunkett W, Ruiz Van Haperen V, et al. Randomized phase II comparison of dose-intense gemcitabine: thirty-minute infusion and fixed dose rate infusion in patients with pancreatic adenocarcinoma. *J Clin Oncol* 2003;21:3402-3408. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12885837>.

224. Poplin E, Feng Y, Berlin J, et al. Phase III, randomized study of gemcitabine and oxaliplatin versus gemcitabine (fixed-dose rate infusion) compared with gemcitabine (30-minute infusion) in patients with pancreatic carcinoma E6201: a trial of the Eastern Cooperative Oncology Group. *J Clin Oncol* 2009;27:3778-3785. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19581537>.

225. Demols A, Peeters M, Polus M, et al. Gemcitabine and oxaliplatin (GEMOX) in gemcitabine refractory advanced pancreatic adenocarcinoma: a phase II study. *Br J Cancer* 2006;94:481-485. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16434988>.

226. Fine RL, Fogelman DR, Schreiber SM, et al. The gemcitabine, docetaxel, and capecitabine (GTX) regimen for metastatic pancreatic cancer: a retrospective analysis. *Cancer Chemother Pharmacol*



2008;61:167-175. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17440727>.

227. Ko AH, Espinoza AM, Jones KA, et al. Optimizing the administration of fixed-dose rate gemcitabine plus capecitabine using an alternating-week schedule: a dose finding and early efficacy study in advanced pancreatic and biliary carcinomas. *Am J Clin Oncol* 2012;35:411-417. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/21552099>.

228. Berlin JD, Catalano P, Thomas JP, et al. Phase III study of gemcitabine in combination with fluorouracil versus gemcitabine alone in patients with advanced pancreatic carcinoma: Eastern Cooperative Oncology Group Trial E2297. *J Clin Oncol* 2002;20:3270-3275.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12149301>.

229. Colucci G, Giuliani F, Gebbia V, et al. Gemcitabine alone or with cisplatin for the treatment of patients with locally advanced and/or metastatic pancreatic carcinoma: a prospective, randomized phase III study of the Gruppo Oncologia dell'Italia Meridionale. *Cancer* 2002;94:902-910. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/11920457>.

230. Colucci G, Labianca R, Di Costanzo F, et al. Randomized phase III trial of gemcitabine plus cisplatin compared with single-agent gemcitabine as first-line treatment of patients with advanced pancreatic cancer: the GIP-1 study. *J Clin Oncol* 2010;28:1645-1651. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/20194854>.

231. Cunningham D, Chau I, Stocken DD, et al. Phase III randomized comparison of gemcitabine versus gemcitabine plus capecitabine in patients with advanced pancreatic cancer. *J Clin Oncol* 2009;27:5513-5518. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19858379>.

232. Heinemann V, Boeck S, Hinke A, et al. Meta-analysis of randomized trials: evaluation of benefit from gemcitabine-based combination chemotherapy applied in advanced pancreatic cancer.

BMC Cancer 2008;8:82-82. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18373843>.

233. Heinemann V, Quietzsch D, Gieseler F, et al. Randomized phase III trial of gemcitabine plus cisplatin compared with gemcitabine alone in advanced pancreatic cancer. *J Clin Oncol* 2006;24:3946-3952.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16921047>.

234. Heinemann V, Labianca R, Hinke A, Louvet C. Increased survival using platinum analog combined with gemcitabine as compared to single-agent gemcitabine in advanced pancreatic cancer: pooled analysis of two randomized trials, the GERCOR/GISCAD intergroup study and a German multicenter study. *Ann Oncol* 2007;18:1652-1659.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17660491>.

235. Herrmann R, Bodoky G, Ruhstaller T, et al. Gemcitabine plus capecitabine compared with gemcitabine alone in advanced pancreatic cancer: a randomized, multicenter, phase III trial of the Swiss Group for Clinical Cancer Research and the Central European Cooperative Oncology Group. *J Clin Oncol* 2007;25:2212-2217. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17538165>.

236. Louvet C, Labianca R, Hammel P, et al. Gemcitabine in combination with oxaliplatin compared with gemcitabine alone in locally advanced or metastatic pancreatic cancer: results of a GERCOR and GISCAD phase III trial. *J Clin Oncol* 2005;23:3509-3516. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15908661>.

237. Reni M, Cordio S, Milandri C, et al. Gemcitabine versus cisplatin, epirubicin, fluorouracil, and gemcitabine in advanced pancreatic cancer: a randomised controlled multicentre phase III trial. *Lancet Oncol* 2005;6:369-376. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15925814>.

238. Rocha Lima CM, Green MR, Rotche R, et al. Irinotecan plus gemcitabine results in no survival advantage compared with gemcitabine monotherapy in patients with locally advanced or metastatic pancreatic cancer despite increased tumor response rate. *J*



NCCN Guidelines Version 2.2016 Pancreatic Adenocarcinoma

Clin Oncol 2004;22:3776-3783. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/15365074>.

239. Ciliberto D, Botta C, Correale P, et al. Role of gemcitabine-based combination therapy in the management of advanced pancreatic cancer: A meta-analysis of randomised trials. Eur J Cancer 2013;49:593-603. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/22989511>.

240. Sun C, Ansari D, Andersson R, Wu DQ. Does gemcitabine-based combination therapy improve the prognosis of unresectable pancreatic cancer? World J Gastroenterol 2012;18:4944-4958. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/23002368>.

241. Kulke MH, Tempero MA, Niedzwiecki D, et al. Randomized phase II study of gemcitabine administered at a fixed dose rate or in combination with cisplatin, docetaxel, or irinotecan in patients with metastatic pancreatic cancer: CALGB 89904. J Clin Oncol 2009;27:5506-5512. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/19858396>.

242. Stathopoulos GP, Syrigos K, Aravantinos G, et al. A multicenter phase III trial comparing irinotecan-gemcitabine (IG) with gemcitabine (G) monotherapy as first-line treatment in patients with locally advanced or metastatic pancreatic cancer. Br J Cancer 2006;95:587-592. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16909140>.

243. Goncalves A, Gilabert M, Francois E, et al. BAYPAN study: a double-blind phase III randomized trial comparing gemcitabine plus sorafenib and gemcitabine plus placebo in patients with advanced pancreatic cancer. Ann Oncol 2012;23:2799-2805. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/22771827>.

244. Von Hoff DD, Ramanathan RK, Borad MJ, et al. Gemcitabine plus nab-paclitaxel is an active regimen in patients with advanced pancreatic cancer: a phase I/II trial. J Clin Oncol 2011;29:4548-4554. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/21969517>.

245. Von Hoff DD, Ervin T, Arena FP, et al. Increased survival in pancreatic cancer with nab-paclitaxel plus gemcitabine. N Engl J Med 2013;369:1691-1703. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/24131140>.

246. Goldstein D, El-Maraghi RH, Hammel P, et al. Analyses of updated overall survival (OS) and prognostic effect of neutrophil-to-lymphocyte ratio (NLR) and CA 19-9 from the phase III MPACT study of nab-paclitaxel (nab-P) plus gemcitabine (Gem) versus Gem for patients (pts) with metastatic pancreatic cancer (PC) [abstract]. ASCO Meeting Abstracts 2014;32:4027. Available at:
http://meeting.ascopubs.org/cqi/content/abstract/32/15_suppl/4027.

247. Chiorean EG, Von Hoff DD, Reni M, et al. CA19-9 decrease at 8 weeks as a predictor of overall survival in a randomized phase III trial (MPACT) of weekly nab-paclitaxel plus gemcitabine versus gemcitabine alone in patients with metastatic pancreatic cancer. Ann Oncol 2016;27:654-660. Available at:
<https://www.ncbi.nlm.nih.gov/pubmed/26802160>.

248. Ramanathan RK, Goldstein D, Korn RL, et al. Positron emission tomography response evaluation from a randomized phase III trial of weekly nab-paclitaxel plus gemcitabine versus gemcitabine alone for patients with metastatic adenocarcinoma of the pancreas. Ann Oncol 2016;27:648-653. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/26802153>.

249. Goldstein D, El-Maraghi RH, Hammel P, et al. nab-Paclitaxel plus gemcitabine for metastatic pancreatic cancer: long-term survival from a phase III trial. J Natl Cancer Inst 2015;107. Available at:
<https://www.ncbi.nlm.nih.gov/pubmed/25638248>.

250. Taberero J, Chiorean EG, Infante JR, et al. Prognostic factors of survival in a randomized phase III trial (MPACT) of weekly nab-paclitaxel plus gemcitabine versus gemcitabine alone in patients with metastatic pancreatic cancer. Oncologist 2015;20:143-150. Available at:
<https://www.ncbi.nlm.nih.gov/pubmed/25582141>.

251. Buccheri G, Ferrigno D, Tamburini M. Karnofsky and ECOG performance status scoring in lung cancer: a prospective, longitudinal study of 536 patients from a single institution. *Eur J Cancer* 1996;32a:1135-1141. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/8758243>.

252. Ma C, Bandukwala S, Burman D, et al. Interconversion of three measures of performance status: an empirical analysis. *Eur J Cancer* 2010;46:3175-3183. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/20674334>.

253. Kindler HL, Friberg G, Singh DA, et al. Phase II trial of bevacizumab plus gemcitabine in patients with advanced pancreatic cancer. *J Clin Oncol* 2005;23:8033-8040. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16258101>.

254. Xiong HQ, Rosenberg A, LoBuglio A, et al. Cetuximab, a monoclonal antibody targeting the epidermal growth factor receptor, in combination with gemcitabine for advanced pancreatic cancer: a multicenter phase II Trial. *J Clin Oncol* 2004;22:2610-2616. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15226328>.

255. Moore MJ, Goldstein D, Hamm J, et al. Erlotinib plus gemcitabine compared with gemcitabine alone in patients with advanced pancreatic cancer: a phase III trial of the National Cancer Institute of Canada Clinical Trials Group. *J Clin Oncol* 2007;25:1960-1966. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17452677>.

256. Philip PA, Benedetti J, Corless CL, et al. Phase III study comparing gemcitabine plus cetuximab versus gemcitabine in patients with advanced pancreatic adenocarcinoma: Southwest Oncology Group-directed intergroup trial S0205. *J Clin Oncol* 2010;28:3605-3610. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20606093>.

257. Kindler HL, Niedzwiecki D, Hollis D, et al. Gemcitabine plus bevacizumab compared with gemcitabine plus placebo in patients with advanced pancreatic cancer: phase III trial of the Cancer and Leukemia

Group B (CALGB 80303). *J Clin Oncol* 2010;28:3617-3622. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20606091>.

258. Kindler HL, Ioka T, Richel DJ, et al. Axitinib plus gemcitabine versus placebo plus gemcitabine in patients with advanced pancreatic adenocarcinoma: a double-blind randomised phase 3 study. *Lancet Oncol* 2011;12:256-262. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21306953>.

259. Van Cutsem E, Vervenne WL, Bennouna J, et al. Phase III trial of bevacizumab in combination with gemcitabine and erlotinib in patients with metastatic pancreatic cancer. *J Clin Oncol* 2009;27:2231-2237. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19307500>.

260. Aranda E, Manzano JL, Rivera F, et al. Phase II open-label study of erlotinib in combination with gemcitabine in unresectable and/or metastatic adenocarcinoma of the pancreas: relationship between skin rash and survival (Pantar study). *Ann Oncol* 2012;23:1919-1925. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22156621>.

261. Stepanski EJ, Reyes C, Walker MS, et al. The association of rash severity with overall survival: findings from patients receiving erlotinib for pancreatic cancer in the community setting. *Pancreas* 2013;42:32-36. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22699203>.

262. Rougier P, Riess H, Manges R, et al. Randomised, placebo-controlled, double-blind, parallel-group phase III study evaluating aflibercept in patients receiving first-line treatment with gemcitabine for metastatic pancreatic cancer. *Eur J Cancer* 2013;49:2633-2642. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23642329>.

263. Ioka T, Okusaka T, Ohkawa S, et al. Efficacy and safety of axitinib in combination with gemcitabine in advanced pancreatic cancer: subgroup analyses by region, including Japan, from the global randomized Phase III trial. *Jpn J Clin Oncol* 2015;45:439-448. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25647781>.

264. O'Neil BH, Scott AJ, Ma WW, et al. A phase II/III randomized study to compare the efficacy and safety of rigosertib plus gemcitabine versus gemcitabine alone in patients with previously untreated metastatic pancreatic cancer. *Ann Oncol* 2015. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/26091808>.

265. Fuchs CS, Azevedo S, Okusaka T, et al. A phase 3 randomized, double-blind, placebo-controlled trial of ganitumab or placebo in combination with gemcitabine as first-line therapy for metastatic adenocarcinoma of the pancreas: the GAMMA trial. *Ann Oncol* 2015;26:921-927. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25609246>.

266. Bergmann L, Maute L, Heil G, et al. A prospective randomised phase-II trial with gemcitabine versus gemcitabine plus sunitinib in advanced pancreatic cancer: a study of the CESAR Central European Society for Anticancer Drug Research-EWIV. *Eur J Cancer* 2015;51:27-36. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25459392>.

267. Golan T, Kanji ZS, Epelbaum R, et al. Overall survival and clinical characteristics of pancreatic cancer in BRCA mutation carriers. *Br J Cancer* 2014;111:1132-1138. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25072261>.

268. Majdak EJ, Debniak J, Milczek T, et al. Prognostic impact of BRCA1 pathogenic and BRCA1/BRCA2 unclassified variant mutations in patients with ovarian carcinoma. *Cancer* 2005;104:1004-1012. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16047333>.

269. Stefansson OA, Jonasson JG, Johannsson OT, et al. Genomic profiling of breast tumours in relation to BRCA abnormalities and phenotypes. *Breast Cancer Res* 2009;11:R47. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19589159>.

270. Oliver GR, Sugar E, Laheru D, Diaz LA. Family history of cancer and sensitivity to platinum chemotherapy in pancreatic adenocarcinoma [abstract]. *Gastrointestinal Cancers Symposium* 2010:180. Available at: <http://meetinglibrary.asco.org/content/2395-72>.

271. Lowery MA, Kelsen DP, Stadler ZK, et al. An emerging entity: pancreatic adenocarcinoma associated with a known BRCA mutation: clinical descriptors, treatment implications, and future directions. *Oncologist* 2011;16:1397-1402. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21934105>.

272. Li Q, Yan H, Liu W, et al. Efficacy and safety of gemcitabine-fluorouracil combination therapy in the management of advanced pancreatic cancer: a meta-analysis of randomized controlled trials. *PLoS One* 2014;9:e104346. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25093849>.

273. De Jesus-Acosta A, Oliver GR, Blackford A, et al. A multicenter analysis of GTX chemotherapy in patients with locally advanced and metastatic pancreatic adenocarcinoma. *Cancer Chemother Pharmacol* 2012;69:415-424. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21800112>.

274. Petrioli R, Roviello G, Fiaschi AI, et al. Gemcitabine, oxaliplatin, and capecitabine (GEMOXEL) compared with gemcitabine alone in metastatic pancreatic cancer: a randomized phase II study. *Cancer Chemother Pharmacol* 2015;75:683-690. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/25454414>.

275. Trouilloud I, Dupont-Gossard AC, Malka D, et al. Fixed-dose rate gemcitabine alone or alternating with FOLFIRI.3 (irinotecan, leucovorin and fluorouracil) in the first-line treatment of patients with metastatic pancreatic adenocarcinoma: an AGEO randomised phase II study (FIRGEM). *Eur J Cancer* 2014;50:3116-3124. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25454414>.

276. Yanagimoto H, Ishii H, Nakai Y, et al. Improved survival with combined gemcitabine and S-1 for locally advanced pancreatic cancer: pooled analysis of three randomized studies. *J Hepatobiliary Pancreat Sci* 2014;21:761-766. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24925464>.

277. Sho M, Shimizu A, Yanagimoto H, et al. Multicenter randomized phase II study comparing alternate-day oral therapy using S-1 with the

standard regimen as a first-line treatment for patients with locally advanced and metastatic pancreatic cancer: PAN-01 study. ASCO Meeting Abstracts 2016;34:4107. Available at: http://meeting.ascopubs.org/cgi/content/abstract/34/15_suppl/4107.

278. Neoptolemos JP, Stocken DD, Friess H, et al. A randomized trial of chemoradiotherapy and chemotherapy after resection of pancreatic cancer. *N Engl J Med* 2004;350:1200-1210. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15028824>.

279. Neoptolemos JP, Stocken DD, Bassi C, et al. Adjuvant chemotherapy with fluorouracil plus folinic acid vs gemcitabine following pancreatic cancer resection: a randomized controlled trial. *JAMA* 2010;304:1073-1081. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20823433>.

280. Comparison of fluorouracil with additional levamisole, higher-dose folinic acid, or both, as adjuvant chemotherapy for colorectal cancer: a randomised trial. QUASAR Collaborative Group. *Lancet* 2000;355:1588-1596. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10821362>.

281. Jager E, Heike M, Bernhard H, et al. Weekly high-dose leucovorin versus low-dose leucovorin combined with fluorouracil in advanced colorectal cancer: results of a randomized multicenter trial. Study Group for Palliative Treatment of Metastatic Colorectal Cancer Study Protocol 1. *J Clin Oncol* 1996;14:2274-2279. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8708717>.

282. O'Connell MJ. A phase III trial of 5-fluorouracil and leucovorin in the treatment of advanced colorectal cancer. A Mayo Clinic/North Central Cancer Treatment Group study. *Cancer* 1989;63:1026-1030. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/2465076>.

283. Ychou M, Conroy T, Seitz JF, et al. An open phase I study assessing the feasibility of the triple combination: oxaliplatin plus irinotecan plus leucovorin/ 5-fluorouracil every 2 weeks in patients with advanced solid tumors. *Ann Oncol* 2003;14:481-489. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12598357>.

284. Conroy T, Paillot B, Francois E, et al. Irinotecan plus oxaliplatin and leucovorin-modulated fluorouracil in advanced pancreatic cancer--a Groupe Tumeurs Digestives of the Federation Nationale des Centres de Lutte Contre le Cancer study. *J Clin Oncol* 2005;23:1228-1236. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15718320>.

285. Ychou M, Desseigne F, Guimbaud R, et al. Randomized phase II trial comparing folfox (5FU/leucovorin [LV], irinotecan [I] and oxaliplatin [O]) vs gemcitabine (G) as first-line treatment for metastatic pancreatic adenocarcinoma (MPA). First results of the ACCORD 11 trial [abstract]. *J Clin Oncol* 2007;25 (June 20 Suppl):4516. Available at: http://meeting.ascopubs.org/cgi/content/abstract/25/18_suppl/4516?sid=8904e4d6-689f-4715-8b08-891737076e04.

286. Conroy T, Desseigne F, Ychou M, et al. FOLFIRINOX versus gemcitabine for metastatic pancreatic cancer. *N Engl J Med* 2011;364:1817-1825. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21561347>.

287. Peixoto RD, Ho M, Renouf DJ, et al. Eligibility of metastatic pancreatic cancer patients for first-line palliative intent nab-paclitaxel plus gemcitabine versus FOLFIRINOX. *Am J Clin Oncol* 2015. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25844823>.

288. Suker M, Beumer BR, Sadot E, et al. FOLFIRINOX for locally advanced pancreatic cancer: a systematic review and patient-level meta-analysis. *Lancet Oncol* 2016;17:801-810. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/27160474>.

289. Sadot E, Doussot A, O'Reilly EM, et al. FOLFIRINOX induction therapy for stage 3 pancreatic adenocarcinoma. *Ann Surg Oncol* 2015;22:3512-3521. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/26065868>.

290. Gourgou-Bourgade S, Bascoul-Mollevi C, Desseigne F, et al. Impact of FOLFIRINOX compared with gemcitabine on quality of life in patients with metastatic pancreatic cancer: results from the PRODIGE

4/ACCORD 11 randomized trial. *J Clin Oncol* 2013;31:23-29. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23213101>.

291. Lowery MA, Yu KH, Adel NG, et al. Activity of front-line FOLFIRINOX (FFX) in stage III/IV pancreatic adenocarcinoma (PC) at Memorial Sloan-Kettering Cancer Center (MSKCC) [abstract]. ASCO Meeting Abstracts 2012;30:4057. Available at: http://meeting.ascopubs.org/cgi/content/abstract/30/15_suppl/4057.

292. Stein SM, James ES, Deng Y, et al. Final analysis of a phase II study of modified FOLFIRINOX in locally advanced and metastatic pancreatic cancer. *Br J Cancer* 2016;114:809-812. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27022826>.

293. Boeck S, Vehling-Kaiser U, Waldschmidt D, et al. Erlotinib 150 mg daily plus chemotherapy in advanced pancreatic cancer: an interim safety analysis of a multicenter, randomized, cross-over phase III trial of the 'Arbeitsgemeinschaft Internistische Onkologie'. *Anticancer Drugs* 2010;21:94-100. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19770635>.

294. Cartwright TH, Cohn A, Varkey JA, et al. Phase II study of oral capecitabine in patients with advanced or metastatic pancreatic cancer. *J Clin Oncol* 2002;20:160-164. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11773165>.

295. Pelzer U, Schwaner I, Stieler J, et al. Best supportive care (BSC) versus oxaliplatin, folinic acid and 5-fluorouracil (OFF) plus BSC in patients for second-line advanced pancreatic cancer: a phase III-study from the German CONKO-study group. *Eur J Cancer* 2011;47:1676-1681. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21565490>.

296. Xiong HQ, Varadhachary GR, Blais JC, et al. Phase 2 trial of oxaliplatin plus capecitabine (XELOX) as second-line therapy for patients with advanced pancreatic cancer. *Cancer* 2008;113:2046-2052. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18756532>.

297. Reni M, Cereda S, Milella M, et al. Maintenance sunitinib or observation in metastatic pancreatic adenocarcinoma: a phase II randomised trial. *Eur J Cancer* 2013;49:3609-3615. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23899530>.

298. Rahma OE, Duffy A, Liewehr DJ, et al. Second-line treatment in advanced pancreatic cancer: a comprehensive analysis of published clinical trials. *Ann Oncol* 2013;24:1972-1979. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23670093>.

299. Maisey N, Chau I, Cunningham D, et al. Multicenter randomized phase III trial comparing protracted venous infusion (PVI) fluorouracil (5-FU) with PVI 5-FU plus mitomycin in inoperable pancreatic cancer. *J Clin Oncol* 2002;20:3130-3136. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12118027>.

300. Pelzer U, Kubica K, Stieler J, et al. A randomized trial in patients with gemcitabine refractory pancreatic cancer. Final results of the CONKO 003 study [abstract]. *J Clin Oncol* 2008;26 (May 20 suppl):4508. Available at: http://meeting.ascopubs.org/cgi/content/abstract/26/15_suppl/4508?sid=31ed1378-2eda-4a39-8a2a-177afb2c9fb4.

301. Saif MW. New developments in the treatment of pancreatic cancer. Highlights from the "44th ASCO Annual Meeting". Chicago, IL, USA. May 30 - June 3, 2008. *JOP* 2008;9:391-397. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18648128>.

302. Oettle H, Riess H, Stieler JM, et al. Second-line oxaliplatin, folinic acid, and fluorouracil versus folinic acid and fluorouracil alone for gemcitabine-refractory pancreatic cancer: outcomes from the CONKO-003 trial. *J Clin Oncol* 2014;32:2423-2429. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24982456>.

303. Gill S, Ko Y-J, Cripps MC, et al. PANCREOX: A randomized phase 3 study of 5FU/LV with or without oxaliplatin for second-line advanced pancreatic cancer (APC) in patients (pts) who have received gemcitabine (GEM)-based chemotherapy (CT) [abstract]. ASCO

Meeting Abstracts 2014;32:4022. Available at:
http://meeting.ascopubs.org/cgi/content/abstract/32/15_suppl/4022.

304. Wang-Gillam A, Li CP, Bodoky G, et al. Nanoliposomal irinotecan with fluorouracil and folinic acid in metastatic pancreatic cancer after previous gemcitabine-based therapy (NAPOLI-1): a global, randomised, open-label, phase 3 trial. *Lancet* 2015. Available at:
<https://www.ncbi.nlm.nih.gov/pubmed/26615328>.

305. Wang-Gillam A, Li C-P, Bodoky G, et al. Updated overall survival (OS) analysis of NAPOLI-1: Phase 3 study of nanoliposomal irinotecan (nal-IRI, MM-398), with or without 5-fluorouracil and leucovorin (5-FU/LV), vs 5-FU/LV in metastatic pancreatic cancer (mPAC) previously treated with gemcitabine (gem)-based therapy. ASCO Meeting Abstracts 2016;34:4126. Available at:
http://meeting.ascopubs.org/cgi/content/abstract/34/15_suppl/4126.

306. Heinemann V, Vehling-Kaiser U, Waldschmidt D, et al. Gemcitabine plus erlotinib followed by capecitabine versus capecitabine plus erlotinib followed by gemcitabine in advanced pancreatic cancer: final results of a randomised phase 3 trial of the 'Arbeitsgemeinschaft Internistische Onkologie' (AIO-PK0104). *Gut* 2013;62:751-759. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22773551>.

307. Seiwert TY, Salama JK, Vokes EE. The concurrent chemoradiation paradigm--general principles. *Nat Clin Pract Oncol* 2007;4:86-100. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17259930>.

308. Kalsner MH, Ellenberg SS. Pancreatic cancer. Adjuvant combined radiation and chemotherapy following curative resection. *Arch Surg* 1985;120:899-903. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/4015380>.

309. Moertel CG, Frytak S, Hahn RG, et al. Therapy of locally unresectable pancreatic carcinoma: a randomized comparison of high dose (6000 rads) radiation alone, moderate dose radiation (4000 rads + 5-fluorouracil), and high dose radiation + 5-fluorouracil: The

Gastrointestinal Tumor Study Group. *Cancer* 1981;48:1705-1710. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7284971>.

310. Klinkenbijn JH, Jeekel J, Sahnoud T, et al. Adjuvant radiotherapy and 5-fluorouracil after curative resection of cancer of the pancreas and periampullary region: phase III trial of the EORTC gastrointestinal tract cancer cooperative group. *Ann Surg* 1999;230:776-782. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/10615932>.

311. Smeenk HG, van Eijck CHJ, Hop WC, et al. Long-term survival and metastatic pattern of pancreatic and periampullary cancer after adjuvant chemoradiation or observation: long-term results of EORTC trial 40891. *Ann Surg* 2007;246:734-740. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/17968163>.

312. Regine WF, Winter KA, Abrams RA, et al. Fluorouracil vs gemcitabine chemotherapy before and after fluorouracil-based chemoradiation following resection of pancreatic adenocarcinoma: a randomized controlled trial. *JAMA* 2008;299:1019-1026. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/18319412>.

313. Garofalo MC, Abrams RA, Regine WF. Adjuvant therapy for pancreatic cancer: no 'definite' standard. *Oncology* 2007;21:726-730. Available at:
<http://www.cancernetwork.com/display/article/10165/61708>.

314. Regine WF, Winter KA, Abrams R, et al. Fluorouracil-based chemoradiation with either gemcitabine or fluorouracil chemotherapy after resection of pancreatic adenocarcinoma: 5-year analysis of the U.S. Intergroup/RTOG 9704 phase III trial. *Ann Surg Oncol* 2011;18:1319-1326. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/21499862>.

315. Crane CH, Ben-Josef E, Small W. Chemotherapy for pancreatic cancer. *N Engl J Med* 2004;350:2713-2715. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/15218575>.

316. Koshy MC, Landry JC, Cavanaugh SX, et al. A challenge to the therapeutic nihilism of ESPAC-1. *Int J Radiat Oncol Biol Phys* 2005;61:965-966. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15752874>.

317. Morris SL, Beasley M, Leslie M. Chemotherapy for pancreatic cancer. *N Engl J Med* 2004;350:2713-2715; author reply 2713-2715.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15215490>.

318. Van Laethem JL, Hammel P, Mornex F, et al. Adjuvant gemcitabine alone versus gemcitabine-based chemoradiotherapy after curative resection for pancreatic cancer: a randomized EORTC-40013-22012/FFCD-9203/GERCOR phase II study. *J Clin Oncol* 2010;28:4450-4456. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/20837948>.

319. Schmidt J, Abel U, Debus J, et al. Open-label, multicenter, randomized phase III trial of adjuvant chemoradiation plus interferon Alfa-2b versus fluorouracil and folinic acid for patients with resected pancreatic adenocarcinoma. *J Clin Oncol* 2012;30:4077-4083. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23008325>.

320. Ren F, Xu YC, Wang HX, et al. Adjuvant chemotherapy, with or without postoperative radiotherapy, for resectable advanced pancreatic adenocarcinoma: continue or stop? *Pancreatology* 2012;12:162-169.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22487527>.

321. Liao WC, Chien KL, Lin YL, et al. Adjuvant treatments for resected pancreatic adenocarcinoma: a systematic review and network meta-analysis. *Lancet Oncol* 2013;14:1095-1103. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24035532>.

322. Kooby DA, Gillespie TW, Liu Y, et al. Impact of adjuvant radiotherapy on survival after pancreatic cancer resection: an appraisal of data from the national cancer data base. *Ann Surg Oncol* 2013;20:3634-3642. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23771249>.

323. Morganti AG, Falconi M, van Stiphout RG, et al. Multi-institutional pooled analysis on adjuvant chemoradiation in pancreatic cancer. *Int J Radiat Oncol Biol Phys* 2014. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/25220717>.

324. Neoptolemos JP, Stocken DD, Dunn JA, et al. Influence of resection margins on survival for patients with pancreatic cancer treated by adjuvant chemoradiation and/or chemotherapy in the ESPAC-1 randomized controlled trial. *Ann Surg* 2001;234:758-768. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/11729382>.

325. Herman JM, Swartz MJ, Hsu CC, et al. Analysis of fluorouracil-based adjuvant chemotherapy and radiation after pancreaticoduodenectomy for ductal adenocarcinoma of the pancreas: results of a large, prospectively collected database at the Johns Hopkins Hospital. *J Clin Oncol* 2008;26:3503-3510. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18640931>.

326. Corsini MM, Miller RC, Haddock MG, et al. Adjuvant radiotherapy and chemotherapy for pancreatic carcinoma: the Mayo Clinic experience (1975-2005). *J Clin Oncol* 2008;26:3511-3516. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18640932>.

327. Hsu CC, Herman JM, Corsini MM, et al. Adjuvant chemoradiation for pancreatic adenocarcinoma: the Johns Hopkins Hospital-Mayo Clinic collaborative study. *Ann Surg Oncol* 2010;17:981-990. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/20087786>.

328. Butturini G, Stocken DD, Wentz MN, et al. Influence of resection margins and treatment on survival in patients with pancreatic cancer: meta-analysis of randomized controlled trials. *Arch Surg* 2008;143:75-83; discussion 83. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18209156>.

329. Redmond KJ, Wolfgang CL, Sugar EA, et al. Adjuvant chemoradiation therapy for adenocarcinoma of the distal pancreas. *Ann Surg Oncol* 2010;17:3112-3119. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/20680697>.

330. Stocken DD, Buchler MW, Dervenis C, et al. Meta-analysis of randomised adjuvant therapy trials for pancreatic cancer. *Br J Cancer* 2005;92:1372-1381. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15812554>.

331. Kim R, Saif MW. Is there an optimal neoadjuvant therapy for locally advanced pancreatic cancer? *JOP* 2007;8:279-288. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17495356>.

332. Chen Y, Sun XJ, Jiang TH, Mao AW. Combined radiochemotherapy in patients with locally advanced pancreatic cancer: a meta-analysis. *World J Gastroenterol* 2013;19:7461-7471. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24259979>.

333. Crane CH, Abbruzzese JL, Evans DB, et al. Is the therapeutic index better with gemcitabine-based chemoradiation than with 5-fluorouracil-based chemoradiation in locally advanced pancreatic cancer? *Int J Radiat Oncol Biol Phys* 2002;52:1293-1302. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11955742>.

334. Blackstock AW, Tepper JE, Niedwiecki D, et al. Cancer and leukemia group B (CALGB) 89805: phase II chemoradiation trial using gemcitabine in patients with locoregional adenocarcinoma of the pancreas. *Int J Gastrointest Cancer* 2003;34:107-116. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15361643>.

335. Girard N, Mornex F, Bossard N, et al. Estimating optimal dose of twice-weekly gemcitabine for concurrent chemoradiotherapy in unresectable pancreatic carcinoma: mature results of GEMRT-01 Phase I trial. *Int J Radiat Oncol Biol Phys* 2010;77:1426-1432. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20056351>.

336. Loehrer PJ, Powell ME, Cardenes HR, et al. A randomized phase III study of gemcitabine in combination with radiation therapy versus gemcitabine alone in patients with localized, unresectable pancreatic cancer: E4201 [abstract]. *J Clin Oncol* 2008;26 (May 20 suppl):4506. Available at:

http://meeting.ascopubs.org/cgi/content/abstract/26/15_suppl/4506?sid=526086db-bb84-4435-b063-52f14bdacd3c.

337. Murphy JD, Adusumilli S, Griffith KA, et al. Full-dose gemcitabine and concurrent radiotherapy for unresectable pancreatic cancer. *Int J Radiat Oncol Biol Phys* 2007;68:801-808. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17379445>.

338. Shibuya K, Oya N, Fujii T, et al. Phase II study of radiation therapy combined with weekly low-dose gemcitabine for locally advanced, unresectable pancreatic cancer. *Am J Clin Oncol* 2010;34:115-119. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20065850>.

339. Huang J, Robertson JM, Margolis J, et al. Long-term results of full-dose gemcitabine with radiation therapy compared to 5-fluorouracil with radiation therapy for locally advanced pancreas cancer. *Radiation Oncol* 2011;99:114-119. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/21621866>.

340. Zhu CP, Shi J, Chen YX, et al. Gemcitabine in the chemoradiotherapy for locally advanced pancreatic cancer: a meta-analysis. *Radiation Oncol* 2011;99:108-113. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/21571383>.

341. Mukherjee S, Hurt CN, Bridgewater J, et al. Gemcitabine-based or capecitabine-based chemoradiotherapy for locally advanced pancreatic cancer (SCALOP): a multicentre, randomised, phase 2 trial. *Lancet Oncol* 2013;14:317-326. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23474363>.

342. Treatment of locally unresectable carcinoma of the pancreas: comparison of combined-modality therapy (chemotherapy plus radiotherapy) to chemotherapy alone. *Gastrointestinal Tumor Study Group. J Natl Cancer Inst* 1988;80:751-755. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/2898536>.

343. Klaassen DJ, MacIntyre JM, Catton GE, et al. Treatment of locally unresectable cancer of the stomach and pancreas: a randomized



comparison of 5-fluorouracil alone with radiation plus concurrent and maintenance 5-fluorouracil--an Eastern Cooperative Oncology Group study. *J Clin Oncol* 1985;3:373-378. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/3973648>.

344. Brunner TB, Grabenbauer GG, Kastl S, et al. Preoperative chemoradiation in locally advanced pancreatic carcinoma: a phase II study. *Onkologie* 2000;23:436-442. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11441238>.

345. Macchia G, Valentini V, Mattiucci GC, et al. Preoperative chemoradiation and intra-operative radiotherapy for pancreatic carcinoma. *Tumori* 2007;93:53-60. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17455872>.

346. Thomas CR, Jr., Weiden PL, Traverso LW, Thompson T. Concomitant intraarterial cisplatin, intravenous 5-fluorouracil, and split-course radiation therapy for locally advanced unresectable pancreatic adenocarcinoma: a phase II study of the Puget Sound Oncology Consortium (PSOC-703). *Am J Clin Oncol* 1997;20:161-165. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9124192>.

347. Cinar P, Ko AH. Evolving treatment options for locally advanced unresectable pancreatic ductal adenocarcinoma. *J Natl Compr Canc Netw* 2014;12:167-172. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24586078>.

348. Loehrer PJ, Sr., Feng Y, Cardenas H, et al. Gemcitabine alone versus gemcitabine plus radiotherapy in patients with locally advanced pancreatic cancer: an Eastern Cooperative Oncology Group trial. *J Clin Oncol* 2011;29:4105-4112. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21969502>.

349. Philip PA. Locally advanced pancreatic cancer: where should we go from here? *J Clin Oncol* 2011;29:4066-4068. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21969514>.

350. Chauffert B, Mornex F, Bonnetain F, et al. Phase III trial comparing intensive induction chemoradiotherapy (60 Gy, infusional 5-FU and intermittent cisplatin) followed by maintenance gemcitabine with gemcitabine alone for locally advanced unresectable pancreatic cancer. Definitive results of the 2000-01 FFCD/SFRO study. *Ann Oncol* 2008;19:1592-1599. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18467316>.

351. Huguet F, Andre T, Hammel P, et al. Impact of chemoradiotherapy after disease control with chemotherapy in locally advanced pancreatic adenocarcinoma in GERCOR phase II and III studies. *J Clin Oncol* 2007;25:326-331. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17235048>.

352. Huguet F, Girard N, Guerche CS-E, et al. Chemoradiotherapy in the management of locally advanced pancreatic carcinoma: a qualitative systematic review. *J Clin Oncol* 2009;27:2269-2277. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19307501>.

353. Krishnan S, Rana V, Janjan NA, et al. Induction chemotherapy selects patients with locally advanced, unresectable pancreatic cancer for optimal benefit from consolidative chemoradiation therapy. *Cancer* 2007;110:47-55. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17538975>.

354. Hammel P, Huguet F, van Laethem JL, et al. Effect of chemoradiotherapy vs chemotherapy on survival in patients with locally advanced pancreatic cancer controlled after 4 months of gemcitabine with or without erlotinib: the LAP07 randomized clinical trial. *Jama* 2016;315:1844-1853. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27139057>.

355. Huguet F, Hammel P, Vernerey D, et al. Impact of chemoradiotherapy (CRT) on local control and time without treatment in patients with locally advanced pancreatic cancer (LAPC) included in the international phase III LAP 07 study [abstract]. *ASCO Meeting Abstracts* 2014;32:4001. Available at: http://meeting.ascopubs.org/cgi/content/abstract/32/15_suppl/4001.



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356. Herman JM, Chang DT, Goodman KA, et al. Phase 2 multi-institutional trial evaluating gemcitabine and stereotactic body radiotherapy for patients with locally advanced unresectable pancreatic adenocarcinoma. *Cancer* 2015;121:1128-1137. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25538019>.

357. Bai YR, Wu GH, Guo WJ, et al. Intensity modulated radiation therapy and chemotherapy for locally advanced pancreatic cancer: results of feasibility study. *World J Gastroenterol* 2003;9:2561-2564. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14606097>.

358. Combs SE, Habermehl D, Kessel K, et al. Intensity modulated radiotherapy as neoadjuvant chemoradiation for the treatment of patients with locally advanced pancreatic cancer. Outcome analysis and comparison with a 3D-treated patient cohort. *Strahlenther Onkol* 2013;189:738-744. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23896630>.

359. Crane CH, Antolak JA, Rosen, II, et al. Phase I study of concomitant gemcitabine and IMRT for patients with unresectable adenocarcinoma of the pancreatic head. *Int J Gastrointest Cancer* 2001;30:123-132. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12540024>.

360. Milano MT, Chmura SJ, Garofalo MC, et al. Intensity-modulated radiotherapy in treatment of pancreatic and bile duct malignancies: toxicity and clinical outcome. *Int J Radiat Oncol Biol Phys* 2004;59:445-453. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15145161>.

361. Spalding AC, Jee K-W, Vineberg K, et al. Potential for dose-escalation and reduction of risk in pancreatic cancer using IMRT optimization with lexicographic ordering and gEUD-based cost functions. *Med Phys* 2007;34:521-529. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17388169>.

362. Bittner MI, Grosu AL, Brunner TB. Comparison of toxicity after IMRT and 3D-conformal radiotherapy for patients with pancreatic

cancer - a systematic review. *Radiother Oncol* 2015;114:117-121. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25497876>.

363. Yovino S, Poppe M, Jabbour S, et al. Intensity-modulated radiation therapy significantly improves acute gastrointestinal toxicity in pancreatic and ampullary cancers. *Int J Radiat Oncol Biol Phys* 2011;79:158-162. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20399035>.

364. Chang DT, Schellenberg D, Shen J, et al. Stereotactic radiotherapy for unresectable adenocarcinoma of the pancreas. *Cancer* 2009;115:665-672. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19117351>.

365. Chuong MD, Springett GM, Freilich JM, et al. Stereotactic body radiation therapy for locally advanced and borderline resectable pancreatic cancer is effective and well tolerated. *Int J Radiat Oncol Biol Phys* 2013;86:516-522. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23562768>.

366. Herman JM, Koong AC. Stereotactic body radiation therapy: a new standard option for pancreatic cancer? *J Natl Compr Canc Netw* 2014;12:1489-1493. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25313185>.

367. Rwigema JC, Parikh SD, Heron DE, et al. Stereotactic body radiotherapy in the treatment of advanced adenocarcinoma of the pancreas. *Am J Clin Oncol* 2011;34:63-69. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20308870>.

368. Tozzi A, Comito T, Alongi F, et al. SBRT in unresectable advanced pancreatic cancer: preliminary results of a mono-institutional experience. *Radiat Oncol* 2013;8:148. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23799996>.

369. Wild AT, Hiniker SM, Chang DT, et al. Re-irradiation with stereotactic body radiation therapy as a novel treatment option for isolated local recurrence of pancreatic cancer after multimodality



therapy: experience from two institutions. *J Gastrointest Oncol* 2013;4:343-351. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24294505>.

370. Gunderson LL, Martin JK, Kvols LK, et al. Intraoperative and external beam irradiation +/- 5-FU for locally advanced pancreatic cancer. *Int J Radiat Oncol Biol Phys* 1987;13:319-329. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/3104244>.

371. Gunderson LL, Martin JK, Jr., Earle JD, et al. Intraoperative and external beam irradiation with or without resection: Mayo pilot experience. *Mayo Clin Proc* 1984;59:691-699. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6482514>.

372. Mohiuddin M, Regine WF, Stevens J, et al. Combined intraoperative radiation and perioperative chemotherapy for unresectable cancers of the pancreas. *J Clin Oncol* 1995;13:2764-2768. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7595736>.

373. Roldan GE, Gunderson LL, Nagorney DM, et al. External beam versus intraoperative and external beam irradiation for locally advanced pancreatic cancer. *Cancer* 1988;61:1110-1116. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/3342371>.

374. Ashman JB, Moss AA, Rule WG, et al. Preoperative chemoradiation and IOERT for unresectable or borderline resectable pancreas cancer. *J Gastrointest Oncol* 2013;4:352-360. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24294506>.

375. Cai S, Hong TS, Goldberg SI, et al. Updated long-term outcomes and prognostic factors for patients with unresectable locally advanced pancreatic cancer treated with intraoperative radiotherapy at the Massachusetts General Hospital, 1978 to 2010. *Cancer* 2013;119:4196-4204. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24006012>.

376. Jingu K, Tanabe T, Nemoto K, et al. Intraoperative radiotherapy for pancreatic cancer: 30-year experience in a single institution in Japan.

Int J Radiat Oncol Biol Phys 2012;83:e507-511. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22445002>.

377. Palta M, Willett C, Czito B. The role of intraoperative radiation therapy in patients with pancreatic cancer. *Semin Radiat Oncol* 2014;24:126-131. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24635869>.

378. Faris JE, Blaszkowsky LS, McDermott S, et al. FOLFIRINOX in locally advanced pancreatic cancer: the Massachusetts General Hospital Cancer Center experience. *Oncologist* 2013;18:543-548. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23657686>.

379. Ammori JB, Colletti LM, Zalupski MM, et al. Surgical resection following radiation therapy with concurrent gemcitabine in patients with previously unresectable adenocarcinoma of the pancreas. *J Gastrointest Surg* 2003;7:766-772. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/13129554>.

380. Bickenbach KA, Gonen M, Tang LH, et al. Downstaging in pancreatic cancer: a matched analysis of patients resected following systemic treatment of initially locally unresectable disease. *Ann Surg Oncol* 2012;19:1663-1669. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22130621>.

381. Habermehl D, Kessel K, Welzel T, et al. Neoadjuvant chemoradiation with Gemcitabine for locally advanced pancreatic cancer. *Radiat Oncol* 2012;7:28. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22385572>.

382. Kadera BE, Sunjaya DB, Isacoff WH, et al. Locally advanced pancreatic cancer: association between prolonged preoperative treatment and lymph-node negativity and overall survival. *JAMA Surg* 2014;149:145-153. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24306217>.

383. Massucco P, Capussotti L, Magnino A, et al. Pancreatic resections after chemoradiotherapy for locally advanced ductal adenocarcinoma:



analysis of perioperative outcome and survival. *Ann Surg Oncol* 2006;13:1201-1208. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/16955382>.

384. Mondo EL, Noel MS, Katz AW, et al. Unresectable locally advanced pancreatic cancer: treatment with neoadjuvant leucovorin, fluorouracil, irinotecan, and oxaliplatin and assessment of surgical resectability. *J Clin Oncol* 2013;31:e37-39. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/23233707>.

385. Mornex F, Girard N, Delpero J-R, Partensky C. Radiochemotherapy in the management of pancreatic cancer--part I: neoadjuvant treatment. *Semin Radiat Oncol* 2005;15:226-234. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/16183476>.

386. Quiros RM, Brown KM, Hoffman JP. Neoadjuvant therapy in pancreatic cancer. *Cancer Invest* 2007;25:267-273. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/17612937>.

387. White RR, Hurwitz HI, Morse MA, et al. Neoadjuvant chemoradiation for localized adenocarcinoma of the pancreas. *Ann Surg Oncol* 2001;8:758-765. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/11776488>.

388. Gillen S, Schuster T, Meyer Zum Buschenfelde C, et al. Preoperative/neoadjuvant therapy in pancreatic cancer: a systematic review and meta-analysis of response and resection percentages. *PLoS Med* 2010;7:e1000267. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/20422030>.

389. Li D, Xie K, Wolff R, Abbruzzese JL. Pancreatic cancer. *Lancet* 2004;363:1049-1057. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/15051286>.

390. Gudjonsson B. Cancer of the pancreas. 50 years of surgery. *Cancer* 1987;60:2284-2303. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/3326653>.

391. Crist DW, Sitzmann JV, Cameron JL. Improved hospital morbidity, mortality, and survival after the Whipple procedure. *Ann Surg* 1987;206:358-365. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/3632096>.

392. Allison DC, Piantadosi S, Hruban RH, et al. DNA content and other factors associated with ten-year survival after resection of pancreatic carcinoma. *J Surg Oncol* 1998;67:151-159. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/9530884>.

393. Howard TJ, Krug JE, Yu J, et al. A margin-negative R0 resection accomplished with minimal postoperative complications is the surgeon's contribution to long-term survival in pancreatic cancer. *J Gastrointest Surg* 2006;10:1338-1345. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/17175452>.

394. Sohn TA, Yeo CJ, Cameron JL, et al. Resected adenocarcinoma of the pancreas-616 patients: results, outcomes, and prognostic indicators. *J Gastrointest Surg* 2000;4:567-579. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/11307091>.

395. Bilimoria KY, Talamonti MS, Sener SF, et al. Effect of hospital volume on margin status after pancreaticoduodenectomy for cancer. *J Am Coll Surg* 2008;207:510-519. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/18926452>.

396. Winter JM, Cameron JL, Campbell KA, et al. 1423 pancreaticoduodenectomies for pancreatic cancer: A single-institution experience. *J Gastrointest Surg* 2006;10:1199-1210; discussion 1210-1191. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17114007>.

397. Zervos EE, Rosemurgy AS, Al-Saif O, Durkin AJ. Surgical management of early-stage pancreatic cancer. *Cancer Control* 2004;11:23-31. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/14749620>.

398. Abrams RA, Lowy AM, O'Reilly EM, et al. Combined modality treatment of resectable and borderline resectable pancreas cancer:



NCCN Guidelines Version 2.2016 Pancreatic Adenocarcinoma

expert consensus statement. *Ann Surg Oncol* 2009;16:1751-1756. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19390900>.

399. Bockhorn M, Uzunoglu FG, Adham M, et al. Borderline resectable pancreatic cancer: a consensus statement by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* 2014;155:977-988. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24856119>.

400. Sobin LH, Gospodarowicz MK, Wittekind C, eds. *TNM Classification of Malignant Tumours* (ed 7th): John Wiley & Sons; 2009.

401. Varadhachary GR, Tamm EP, Abbruzzese JL, et al. Borderline resectable pancreatic cancer: definitions, management, and role of preoperative therapy. *Ann Surg Oncol* 2006;13:1035-1046. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16865597>.

402. Katz MH, Marsh R, Herman JM, et al. Borderline resectable pancreatic cancer: need for standardization and methods for optimal clinical trial design. *Ann Surg Oncol* 2013;20:2787-2795. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23435609>.

403. Talamonti M. Borderline resectable pancreatic cancer: a new classification for an old challenge. *Ann Surg Oncol* 2006;13:1019-1020. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16865593>.

404. Gumbs AA, Rodriguez Rivera AM, Milone L, Hoffman JP. Laparoscopic pancreatoduodenectomy: a review of 285 published cases. *Ann Surg Oncol* 2011;18:1335-1341. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21207166>.

405. Venkat R, Edil BH, Schulick RD, et al. Laparoscopic distal pancreatectomy is associated with significantly less overall morbidity compared to the open technique: a systematic review and meta-analysis. *Ann Surg* 2012;255:1048-1059. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22511003>.

406. Nakeeb A, Lillemoe KD, Grosfeld JL. Surgical techniques for pancreatic cancer. *Minerva Chir* 2004;59:151-163. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15238889>.

407. Yeo TP, Hruban RH, Leach SD, et al. Pancreatic cancer. *Curr Probl Cancer* 2002;26:176-275. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12399802>.

408. Baque P, Iannelli A, Delotte J, et al. Division of the right posterior attachments of the head of the pancreas with a linear stapler during pancreaticoduodenectomy: vascular and oncological considerations based on an anatomical cadaver-based study. *Surg Radiol Anat* 2009;31:13-17. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18712270>.

409. Evans DB, Pisters PW. Novel applications of endo GIA linear staplers during pancreaticoduodenectomy and total pancreatectomy. *Am J Surg* 2003;185:606-607. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12781900>.

410. Kooby DA, Lad NL, Squires MH, 3rd, et al. Value of intraoperative neck margin analysis during Whipple for pancreatic adenocarcinoma: a multicenter analysis of 1399 patients. *Ann Surg* 2014;260:494-501; discussion 501-493. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25115425>.

411. Harrison LE, Klimstra DS, Brennan MF. Isolated portal vein involvement in pancreatic adenocarcinoma. A contraindication for resection? *Ann Surg* 1996;224:342-347; discussion 347-349. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8813262>.

412. Riediger H, Makowiec F, Fischer E, et al. Postoperative morbidity and long-term survival after pancreaticoduodenectomy with superior mesenterico-portal vein resection. *J Gastrointest Surg* 2006;10:1106-1115. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16966029>.

413. Tseng JF, Raut CP, Lee JE, et al. Pancreaticoduodenectomy with vascular resection: margin status and survival duration. *J Gastrointest*



NCCN Guidelines Version 2.2016 Pancreatic Adenocarcinoma

Surg 2004;8:935-949. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/15585381>.

414. Stitzenberg KB, Watson JC, Roberts A, et al. Survival after pancreatectomy with major arterial resection and reconstruction. *Ann Surg Oncol* 2008;15:1399-1406. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/18320285>.

415. Mollberg N, Rahbari NN, Koch M, et al. Arterial resection during pancreatectomy for pancreatic cancer: a systematic review and meta-analysis. *Ann Surg* 2011;254:882-893. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22064622>.

416. Worni M, Castleberry AW, Clary BM, et al. Concomitant vascular reconstruction during pancreatectomy for malignant disease: a propensity score-adjusted, population-based trend analysis involving 10 206 patients. *Arch Surg* 2012;1-8. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/23247767>.

417. Christein JD, Kendrick ML, Iqbal CW, et al. Distal pancreatectomy for resectable adenocarcinoma of the body and tail of the pancreas. *J Gastrointest Surg* 2005;9:922-927. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/16137585>.

418. Shoup M, Conlon KC, Klimstra D, Brennan MF. Is extended resection for adenocarcinoma of the body or tail of the pancreas justified? *J Gastrointest Surg* 2003;7:946-952; discussion 952. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14675703>.

419. Strasberg SM, Linehan DC, Hawkins WG. Radical antegrade modular pancreatectomy procedure for adenocarcinoma of the body and tail of the pancreas: ability to obtain negative tangential margins. *J Am Coll Surg* 2007;204:244-249. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17254928>.

420. Mehrabi A, Hafezi M, Arvin J, et al. A systematic review and meta-analysis of laparoscopic versus open distal pancreatectomy for benign and malignant lesions of the pancreas: it's time to randomize. *Surgery*

2015;157:45-55. Available at:

<https://www.ncbi.nlm.nih.gov/pubmed/25482464>.

421. Stauffer JA, Rosales-Velderrain A, Goldberg RF, et al. Comparison of open with laparoscopic distal pancreatectomy: a single institution's transition over a 7-year period. *HPB (Oxford)* 2013;15:149-155. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23297726>.

422. Pericleous S, Middleton N, McKay SC, et al. Systematic review and meta-analysis of case-matched studies comparing open and laparoscopic distal pancreatectomy: is it a safe procedure? *Pancreas* 2012;41:993-1000. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22836858>.

423. Tran Cao HS, Lopez N, Chang DC, et al. Improved perioperative outcomes with minimally invasive distal pancreatectomy: results from a population-based analysis. *JAMA Surg* 2014;149:237-243. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24402232>.

424. Fortner JG. Regional pancreatectomy for cancer of the pancreas, ampulla, and other related sites. Tumor staging and results. *Ann Surg* 1984;199:418-425. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/6712317>.

425. Fuhrman GM, Leach SD, Staley CA, et al. Rationale for en bloc vein resection in the treatment of pancreatic adenocarcinoma adherent to the superior mesenteric-portal vein confluence. *Pancreatic Tumor Study Group. Ann Surg* 1996;223:154-162. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/8597509>.

426. Leach SD, Lee JE, Charnsangavej C, et al. Survival following pancreaticoduodenectomy with resection of the superior mesenteric-portal vein confluence for adenocarcinoma of the pancreatic head. *Br J Surg* 1998;85:611-617. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/9635805>.

427. Clavien PA, Rudiger HA. A simple technique of portal vein resection and reconstruction during pancreaticoduodenectomy. *J Am*

Coll Surg 1999;189:629-634. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/10589601>.

428. Launois B, Stasik C, Bardaxoglou E, et al. Who benefits from portal vein resection during pancreaticoduodenectomy for pancreatic cancer? World J Surg 1999;23:926-929. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/10449822>.

429. Taschieri AM, Elli M, Rovati M, et al. Surgical treatment of pancreatic tumors invading the spleno-mesenteric-portal vessels. An Italian Multicenter Survey. Hepatogastroenterology 1999;46:492-497. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10228849>.

430. van Geenen RC, ten Kate FJ, de Wit LT, et al. Segmental resection and wedge excision of the portal or superior mesenteric vein during pancreatoduodenectomy. Surgery 2001;129:158-163. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11174708>.

431. Yu XZ, Li J, Fu DL, et al. Benefit from synchronous portal-superior mesenteric vein resection during pancreaticoduodenectomy for cancer: a meta-analysis. Eur J Surg Oncol 2014;40:371-378. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24560302>.

432. Kelly KJ, Winslow E, Kooby D, et al. Vein involvement during pancreaticoduodenectomy: is there a need for redefinition of "borderline resectable disease"? J Gastrointest Surg 2013;17:1209-1217; discussion 1217. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23620151>.

433. Traverso LW, Longmire WP, Jr. Preservation of the pylorus in pancreaticoduodenectomy. Surg Gynecol Obstet 1978;146:959-962. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/653575>.

434. Yeo CJ, Cameron JL, Sohn TA, et al. Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. Ann Surg 1997;226:248-257. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9339931>.

435. van Berge Henegouwen MI, van Gulik TM, DeWit LT, et al. Delayed gastric emptying after standard pancreaticoduodenectomy versus pylorus-preserving pancreaticoduodenectomy: an analysis of 200 consecutive patients. J Am Coll Surg 1997;185:373-379. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9328386>.

436. Kozuschek W, Reith HB, Waleczek H, et al. A comparison of long term results of the standard Whipple procedure and the pylorus preserving pancreatoduodenectomy. J Am Coll Surg 1994;178:443-453. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7909485>.

437. Lin PW, Lin YJ. Prospective randomized comparison between pylorus-preserving and standard pancreaticoduodenectomy. Br J Surg 1999;86:603-607. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10361177>.

438. Matsumoto I, Shinzeki M, Asari S, et al. A prospective randomized comparison between pylorus- and subtotal stomach-preserving pancreatoduodenectomy on postoperative delayed gastric emptying occurrence and long-term nutritional status. J Surg Oncol 2014;109:690-696. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24619624>.

439. Morel P, Mathey P, Corboud H, et al. Pylorus-preserving duodenopancreatectomy: long-term complications and comparison with the Whipple procedure. World J Surg 1990;14:642-646. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/2238666>.

440. Roder JD, Stein HJ, Huttl W, Siewert JR. Pylorus-preserving versus standard pancreatico-duodenectomy: an analysis of 110 pancreatic and periampullary carcinomas. Br J Surg 1992;79:152-155. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/1348201>.

441. Seiler CA, Wagner M, Sadowski C, et al. Randomized prospective trial of pylorus-preserving vs. Classic duodenopancreatectomy (Whipple procedure): initial clinical results. J Gastrointest Surg 2000;4:443-452. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11077317>.

442. Yeo CJ, Cameron JL, Maher MM, et al. A prospective randomized trial of pancreaticogastrostomy versus pancreaticojejunostomy after pancreaticoduodenectomy. *Ann Surg* 1995;222:580-588. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7574936>.

443. Topal B, Fieuws S, Aerts R, et al. Pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy for pancreatic or periampullary tumours: a multicentre randomised trial. *Lancet Oncol* 2013;14:655-662. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23643139>.

444. Wolfgang CL, Pawlik TM. Pancreaticoduodenectomy: time to change our approach? *Lancet Oncol* 2013;14:573-575. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23643140>.

445. Hallet J, Zih FS, Deobald RG, et al. The impact of pancreaticojejunostomy versus pancreaticogastrostomy reconstruction on pancreatic fistula after pancreaticoduodenectomy: meta-analysis of randomized controlled trials. *HPB (Oxford)* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25040921>.

446. Gomez T, Palomares A, Serradilla M, Tejedor L. Reconstruction after pancreatoduodenectomy: Pancreatojejunostomy vs pancreatogastrostomy. *World J Gastrointest Oncol* 2014;6:369-376. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25232462>.

447. Bassi C, Falconi M, Molinari E, et al. Duct-to-mucosa versus end-to-side pancreaticojejunostomy reconstruction after pancreaticoduodenectomy: results of a prospective randomized trial. *Surgery* 2003;134:766-771. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14639354>.

448. Sikora SS, Posner MC. Management of the pancreatic stump following pancreaticoduodenectomy. *Br J Surg* 1995;82:1590-1597. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/8548218>.

449. Strasberg SM, Drebin JA, Mokadam NA, et al. Prospective trial of a blood supply-based technique of pancreaticojejunostomy: effect on

anastomotic failure in the Whipple procedure. *J Am Coll Surg* 2002;194:746-758. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12081065>.

450. Winter JM, Cameron JL, Campbell KA, et al. Does pancreatic duct stenting decrease the rate of pancreatic fistula following pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 2006;10:1280-1290. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17114014>.

451. Lowy AM, Lee JE, Pisters PW, et al. Prospective, randomized trial of octreotide to prevent pancreatic fistula after pancreaticoduodenectomy for malignant disease. *Ann Surg* 1997;226:632-641. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9389397>.

452. Yeo CJ, Cameron JL, Lillemoe KD, et al. Does prophylactic octreotide decrease the rates of pancreatic fistula and other complications after pancreaticoduodenectomy? Results of a prospective randomized placebo-controlled trial. *Ann Surg* 2000;232:419-429. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10973392>.

453. Allen PJ, Gonen M, Brennan MF, et al. Pasireotide for postoperative pancreatic fistula. *N Engl J Med* 2014;370:2014-2022. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24849084>.

454. Lillemoe KD, Cameron JL, Kim MP, et al. Does fibrin glue sealant decrease the rate of pancreatic fistula after pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 2004;8:766-772. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15531229>.

455. Cubilla AL, Fortner J, Fitzgerald PJ. Lymph node involvement in carcinoma of the head of the pancreas area. *Cancer* 1978;41:880-887. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/638975>.

456. Nagai H, Kuroda A, Morioka Y. Lymphatic and local spread of T1 and T2 pancreatic cancer. A study of autopsy material. *Ann Surg*

1986;204:65-71. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/3015059>.

457. Glanemann M, Shi B, Liang F, et al. Surgical strategies for treatment of malignant pancreatic tumors: extended, standard or local surgery? *World J Surg Oncol* 2008;6:123. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/19014474>.

458. Pisters P, Brennan M. Regional lymph node dissection for pancreatic adenocarcinoma. In: Evans D, Pisters P, Abbruzzese J, eds., eds. *Pancreatic Cancer*. New York: Springer-Verlag; 2002:139-151.

459. Pedrazzoli S, DiCarlo V, Dionigi R, et al. Standard versus extended lymphadenectomy associated with pancreatoduodenectomy in the surgical treatment of adenocarcinoma of the head of the pancreas: a multicenter, prospective, randomized study. Lymphadenectomy Study Group. *Ann Surg* 1998;228:508-517.

Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9790340>.

460. Yeo CJ, Cameron JL, Sohn TA, et al. Pancreaticoduodenectomy with or without extended retroperitoneal lymphadenectomy for periampullary adenocarcinoma: comparison of morbidity and mortality and short-term outcome. *Ann Surg* 1999;229:613-622; discussion 622-614. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10235519>.

461. Riall TS, Cameron JL, Lillemoe KD, et al. Pancreaticoduodenectomy with or without distal gastrectomy and extended retroperitoneal lymphadenectomy for periampullary adenocarcinoma--part 3: update on 5-year survival. *J Gastrointest Surg* 2005;9:1191-1204; discussion 1204-1196. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/16332474>.

462. Yeo CJ, Cameron JL, Lillemoe KD, et al. Pancreaticoduodenectomy with or without distal gastrectomy and extended retroperitoneal lymphadenectomy for periampullary adenocarcinoma, part 2: randomized controlled trial evaluating survival, morbidity, and mortality. *Ann Surg* 2002;236:355-366; discussion 366-358. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12192322>.

463. Nimura Y, Nagino M, Takao S, et al. Standard versus extended lymphadenectomy in radical pancreatoduodenectomy for ductal adenocarcinoma of the head of the pancreas: long-term results of a Japanese multicenter randomized controlled trial. *J Hepatobiliary Pancreat Sci* 2012;19:230-241. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/22038501>.

464. Michalski CW, Kleeff J, Wente MN, et al. Systematic review and meta-analysis of standard and extended lymphadenectomy in pancreaticoduodenectomy for pancreatic cancer. *Br J Surg* 2007;94:265-273. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/17318801>.

465. Sun J, Yang Y, Wang X, et al. Meta-analysis of the Efficacies of Extended and Standard Pancreatoduodenectomy for Ductal Adenocarcinoma of the Head of the Pancreas. *World J Surg* 2014;38:2708-2715. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/24912627>.

466. Tol JA, Gouma DJ, Bassi C, et al. Definition of a standard lymphadenectomy in surgery for pancreatic ductal adenocarcinoma: a consensus statement by the International Study Group on Pancreatic Surgery (ISGPS). *Surgery* 2014;156:591-600. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/25061003>.

467. Farnell MB, Aranha GV, Nimura Y, Michelassi F. The role of extended lymphadenectomy for adenocarcinoma of the head of the pancreas: strength of the evidence. *J Gastrointest Surg* 2008;12:651-656. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18085343>.

468. Shrikhande SV, Barreto SG. Extended pancreatic resections and lymphadenectomy: An appraisal of the current evidence. *World J Gastrointest Surg* 2010;2:39-46. Available at:

<http://www.ncbi.nlm.nih.gov/pubmed/21160848>.

469. Cordera F, Arciero CA, Li T, et al. Significance of common hepatic artery lymph node metastases during pancreaticoduodenectomy for



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pancreatic head adenocarcinoma. *Ann Surg Oncol* 2007;14:2330-2336. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17492334>.

470. Shimada K, Sakamoto Y, Sano T, Kosuge T. The role of paraaortic lymph node involvement on early recurrence and survival after macroscopic curative resection with extended lymphadenectomy for pancreatic carcinoma. *J Am Coll Surg* 2006;203:345-352. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16931307>.

471. Bottger TC, Junginger T. Factors influencing morbidity and mortality after pancreaticoduodenectomy: critical analysis of 221 resections. *World J Surg* 1999;23:164-171. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9880426>.

472. Braasch JW, Gray BN. Considerations that lower pancreatoduodenectomy mortality. *Am J Surg* 1977;133:480-484. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/848682>.

473. Lerut JP, Gianello PR, Otte JB, Kestens PJ. Pancreaticoduodenal resection. Surgical experience and evaluation of risk factors in 103 patients. *Ann Surg* 1984;199:432-437. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6712319>.

474. Gundry SR, Strodel WE, Knol JA, et al. Efficacy of preoperative biliary tract decompression in patients with obstructive jaundice. *Arch Surg* 1984;119:703-708. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6428380>.

475. Hatfield AR, Tobias R, Terblanche J, et al. Preoperative external biliary drainage in obstructive jaundice. A prospective controlled clinical trial. *Lancet* 1982;2:896-899. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6126752>.

476. Heslin MJ, Brooks AD, Hochwald SN, et al. A preoperative biliary stent is associated with increased complications after pancreatoduodenectomy. *Arch Surg* 1998;133:149-154. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9484726>.

477. Lai EC, Mok FP, Fan ST, et al. Preoperative endoscopic drainage for malignant obstructive jaundice. *Br J Surg* 1994;81:1195-1198. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7741850>.

478. McPherson GA, Benjamin IS, Hodgson HJ, et al. Pre-operative percutaneous transhepatic biliary drainage: the results of a controlled trial. *Br J Surg* 1984;71:371-375. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6372935>.

479. Pitt HA, Gomes AS, Lois JF, et al. Does preoperative percutaneous biliary drainage reduce operative risk or increase hospital cost? *Ann Surg* 1985;201:545-553. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/2986562>.

480. Thomas JH, Connor CS, Pierce GE, et al. Effect of biliary decompression on morbidity and mortality of pancreatoduodenectomy. *Am J Surg* 1984;148:727-731. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/6439064>.

481. Cavell LK, Allen PJ, Vinoya C, et al. Biliary self-expandable metal stents do not adversely affect pancreaticoduodenectomy. *Am J Gastroenterol* 2013;108:1168-1173. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23545711>.

482. van der Gaag NA, Rauws EA, van Eijck CH, et al. Preoperative biliary drainage for cancer of the head of the pancreas. *N Engl J Med* 2010;362:129-137. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20071702>.

483. Pisters PW, Hudec WA, Hess KR, et al. Effect of preoperative biliary decompression on pancreaticoduodenectomy-associated morbidity in 300 consecutive patients. *Ann Surg* 2001;234:47-55. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11420482>.

484. Aadam AA, Evans DB, Khan A, et al. Efficacy and safety of self-expandable metal stents for biliary decompression in patients receiving neoadjuvant therapy for pancreatic cancer: a prospective study.



Gastrointest Endosc 2012;76:67-75. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/22483859>.

485. Mullen JT, Lee JH, Gomez HF, et al. Pancreaticoduodenectomy after placement of endobiliary metal stents. J Gastrointest Surg 2005;9:1094-1104; discussion 1104-1095. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/16269380>.

486. Varadhachary GR, Wolff RA, Crane CH, et al. Preoperative gemcitabine and cisplatin followed by gemcitabine-based chemoradiation for resectable adenocarcinoma of the pancreatic head. J Clin Oncol 2008;26:3487-3495. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/18640929>.

487. Varadhachary GR, Wolff RA. The war on pancreatic cancer: are we gaining ground? Oncology 2011;24:1335-1336. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/21294479>.

488. Krokidis M, Fanelli F, Orgera G, et al. Percutaneous palliation of pancreatic head cancer: randomized comparison of ePTFE/FEP-covered versus uncovered nitinol biliary stents. Cardiovasc Intervent Radiol 2010;34:352-361. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/20467870>.

489. Kullman E, Frozanpor F, Soderlund C, et al. Covered versus uncovered self-expandable nitinol stents in the palliative treatment of malignant distal biliary obstruction: results from a randomized, multicenter study. Gastrointest Endosc 2010;72:915-923. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/21034892>.

490. Chun HJ, Kim ES, Hyun JJ, et al. Gastrointestinal and biliary stents. J Gastroenterol Hepatol 2010;25:234-243. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/20136988>.

491. Ho H, Mahajan A, Gosain S, et al. Management of complications associated with partially covered biliary metal stents. Dig Dis Sci 2010;55:516-522. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/19267200>.

492. Telford JJ, Carr-Locke DL, Baron TH, et al. A randomized trial comparing uncovered and partially covered self-expandable metal stents in the palliation of distal malignant biliary obstruction. Gastrointest Endosc 2010;72:907-914. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/21034891>.

493. Lieberman MD, Kilburn H, Lindsey M, Brennan MF. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. Ann Surg 1995;222:638-645. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7487211>.

494. Gordon TA, Burleyson GP, Tielsch JM, Cameron JL. The effects of regionalization on cost and outcome for one general high-risk surgical procedure. Ann Surg 1995;221:43-49. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/7826160>.

495. Ho V, Heslin MJ. Effect of hospital volume and experience on in-hospital mortality for pancreaticoduodenectomy. Ann Surg 2003;237:509-514. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/12677147>.

496. Imperato PJ, Nenner RP, Starr HA, et al. The effects of regionalization on clinical outcomes for a high risk surgical procedure: a study of the Whipple procedure in New York State. Am J Med Qual 1996;11:193-197. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/8972936>.

497. Rosemurgy AS, Bloomston M, Serafini FM, et al. Frequency with which surgeons undertake pancreaticoduodenectomy determines length of stay, hospital charges, and in-hospital mortality. J Gastrointest Surg 2001;5:21-26. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/11309644>.

498. Sosa JA, Bowman HM, Gordon TA, et al. Importance of hospital volume in the overall management of pancreatic cancer. Ann Surg 1998;228:429-438. Available at:
<http://www.ncbi.nlm.nih.gov/pubmed/9742926>.

499. Gouma DJ, van Geenen RC, van Gulik TM, et al. Rates of complications and death after pancreaticoduodenectomy: risk factors and the impact of hospital volume. *Ann Surg* 2000;232:786-795. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11088073>.

500. Simunovic M, To T, Theriault M, Langer B. Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system. *CMAJ* 1999;160:643-648. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10101998>.

501. van Heek NT, Kuhlmann KF, Scholten RJ, et al. Hospital volume and mortality after pancreatic resection: a systematic review and an evaluation of intervention in the Netherlands. *Ann Surg* 2005;242:781-788, discussion 788-790. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16327488>.

502. Birkmeyer JD, Finlayson SR, Tosteson AN, et al. Effect of hospital volume on in-hospital mortality with pancreaticoduodenectomy. *Surgery* 1999;125:250-256. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10076608>.

503. Birkmeyer JD, Siewers AE, Finlayson EVA, et al. Hospital volume and surgical mortality in the United States. *N Engl J Med* 2002;346:1128-1137. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11948273>.

504. Bilimoria KY, Bentrem DJ, Ko CY, et al. Multimodality therapy for pancreatic cancer in the U.S.: utilization, outcomes, and the effect of hospital volume. *Cancer* 2007;110:1227-1234. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17654662>.

505. La Torre M, Nigri G, Ferrari L, et al. Hospital volume, margin status, and long-term survival after pancreaticoduodenectomy for pancreatic adenocarcinoma. *Am Surg* 2012;78:225-229. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22369834>.

506. Hyder O, Dodson RM, Nathan H, et al. Influence of patient, physician, and hospital factors on 30-day readmission following

pancreatoduodenectomy in the United States. *JAMA Surg* 2013;148:1095-1102. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24108580>.

507. Verbeke CS. Resection margins and R1 rates in pancreatic cancer--are we there yet? *Histopathology* 2008;52:787-796. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18081813>.

508. Tang LH, Berlin J, Branton P, et al. Protocol for the examination of specimens from patients with carcinoma of the exocrine pancreas. 2013. Available at: http://www.cap.org/apps/docs/committees/cancer/cancer_protocols/2013/PancreasEndo_13protocol_3201.pdf.

509. Gebhardt C, Meyer W, Reichel M, Wunsch PH. Prognostic factors in the operative treatment of ductal pancreatic carcinoma. *Langenbecks Arch Surg* 2000;385:14-20. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10664114>.

510. Mitsunaga S, Hasebe T, Iwasaki M, et al. Important prognostic histological parameters for patients with invasive ductal carcinoma of the pancreas. *Cancer Sci* 2005;96:858-865. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16367904>.

511. Huebner M, Kendrick M, Reid-Lombardo KM, et al. Number of lymph nodes evaluated: prognostic value in pancreatic adenocarcinoma. *J Gastrointest Surg* 2012;16:920-926. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22421988>.

512. Opfermann KJ, Wahlquist AE, Garrett-Mayer E, et al. Adjuvant radiotherapy and lymph node status for pancreatic cancer: results of a study from the Surveillance, Epidemiology, and End Results (SEER) Registry Data. *Am J Clin Oncol* 2014;37:112-116. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23211221>.

513. Valsangkar NP, Bush DM, Michaelson JS, et al. N0/N1, PNL, or LNR? The effect of lymph node number on accurate survival prediction

in pancreatic ductal adenocarcinoma. *J Gastrointest Surg* 2013;17:257-266. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23229885>.

514. Ashfaq A, Pockaj BA, Gray RJ, et al. Nodal counts and lymph node ratio impact survival after distal pancreatectomy for pancreatic adenocarcinoma. *J Gastrointest Surg* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24916590>.

515. John BJ, Naik P, Ironside A, et al. Redefining the R1 resection for pancreatic ductal adenocarcinoma: tumour lymph nodal burden and lymph node ratio are the only prognostic factors associated with survival. *HPB (Oxford)* 2013;15:674-680. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23458477>.

516. Robinson SM, Rahman A, Haugk B, et al. Metastatic lymph node ratio as an important prognostic factor in pancreatic ductal adenocarcinoma. *Eur J Surg Oncol* 2012;38:333-339. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22317758>.

517. Shamseddine AI, Mukherji D, Melki C, et al. Lymph node ratio is an independent prognostic factor after resection of periampullary malignancies: data from a tertiary referral center in the middle East. *Am J Clin Oncol* 2014;37:13-18. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23111358>.

518. Wentz SC, Zhao ZG, Shyr Y, et al. Lymph node ratio and preoperative CA 19-9 levels predict overall survival and recurrence-free survival in patients with resected pancreatic adenocarcinoma. *World J Gastrointest Oncol* 2012;4:207-215. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23444312>.

519. Classification of pancreatic cancer (ed 2). Tokyo: Kanehara, Japan Pancreas Society 2003.

520. Campbell F, Foulis AK, Verbeke CC. Dataset for the histopathological reporting of carcinomas of the pancreas, ampulla of Vater and common bile duct. The Royal College of Pathologists 2010. Available at:

<http://www.rcpath.org/Resources/RCPPath/Migrated%20Resources/Documents/D/datasethistopathologicalreportingcarcinomasmay10.pdf>.

521. Hruban RH, Pitman MB, Klimstra DS. Tumors of the Pancreas: Afip Atlas of Tumor Pathology; 4th Series Fascicle 6: American Registry of Pathology; Armed Forces Institutes of Pathology; 2007.

522. Konstantinidis IT, Warshaw AL, Allen JN, et al. Pancreatic ductal adenocarcinoma: is there a survival difference for R1 resections versus locally advanced unresectable tumors? What is a "true" R0 resection? *Ann Surg* 2013;257:731-736. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22968073>.

523. Frampton AE, Gall TM, Krell J, et al. Is there a 'margin' for error in pancreatic cancer surgery? *Future Oncol* 2013;9:31-34. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23252561>.

524. Gnerlich JL, Luka SR, Deshpande AD, et al. Microscopic margins and patterns of treatment failure in resected pancreatic adenocarcinoma. *Arch Surg* 2012;147:753-760. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22911074>.

525. Delpero JR, Bachellier P, Regenet N, et al. Pancreaticoduodenectomy for pancreatic ductal adenocarcinoma: a French multicentre prospective evaluation of resection margins in 150 evaluable specimens. *HPB (Oxford)* 2014;16:20-33. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23464850>.

526. Neoptolemos JP, Palmer D, Ghaneh P, et al. ESPAC-4: A multicenter, international, open-label randomized controlled phase III trial of adjuvant combination chemotherapy of gemcitabine (GEM) and capecitabine (CAP) versus monotherapy gemcitabine in patients with resected pancreatic ductal adenocarcinoma. *ASCO Meeting Abstracts* 2016;34:LBA4006. Available at: http://meeting.ascopubs.org/cgi/content/abstract/34/15_suppl/LBA4006.

527. Sinn M, Liersch T, Gellert K, et al. CONKO-005: Adjuvant therapy in R0 resected pancreatic cancer patients with gemcitabine plus

erlotinib versus gemcitabine for 24 weeks--A prospective randomized phase III study. ASCO Meeting Abstracts 2015;33:4007. Available at: http://meeting.ascopubs.org/cgi/content/abstract/33/15_suppl/4007.

528. Valle JW, Palmer D, Jackson R, et al. Optimal duration and timing of adjuvant chemotherapy after definitive surgery for ductal adenocarcinoma of the pancreas: ongoing lessons from the ESPAC-3 study. *J Clin Oncol* 2014;32:504-512. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24419109>.

529. Uesaka K, Boku N, Fukutomi A, et al. Adjuvant chemotherapy of S-1 versus gemcitabine for resected pancreatic cancer: a phase 3, open-label, randomised, non-inferiority trial (JASPAC 01). *Lancet* 2016. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/27265347>.

530. Reni M. Neoadjuvant treatment for resectable pancreatic cancer: time for phase III testing? *World J Gastroenterol* 2010;16:4883-4887. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20954273>.

531. Araujo RL, Gaujoux S, Huguet F, et al. Does pre-operative chemoradiation for initially unresectable or borderline resectable pancreatic adenocarcinoma increase post-operative morbidity? A case-matched analysis. *HPB (Oxford)* 2013;15:574-580. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23458208>.

532. Lim KH, Chung E, Khan A, et al. Neoadjuvant therapy of pancreatic cancer: the emerging paradigm? *Oncologist* 2012;17:192-200. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22250057>.

533. Dholakia AS, Hacker-Prietz A, Wild AT, et al. Resection of borderline resectable pancreatic cancer after neoadjuvant chemoradiation does not depend on improved radiographic appearance of tumor–vessel relationships. *J Radiat Oncol* 2013;2:413-425. Available at: <http://citations.springer.com/item?doi=10.1007/s13566-013-0115-6>.

534. Katz MH, Fleming JB, Bhosale P, et al. Response of borderline resectable pancreatic cancer to neoadjuvant therapy is not reflected by

radiographic indicators. *Cancer* 2012;118:5749-5756. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22605518>.

535. Esnaola NF, Chaudhary UB, O'Brien P, et al. Phase 2 trial of induction gemcitabine, oxaliplatin, and cetuximab followed by selective capecitabine-based chemoradiation in patients with borderline resectable or unresectable locally advanced pancreatic cancer. *Int J Radiat Oncol Biol Phys* 2014;88:837-844. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24606850>.

536. Festa V, Andriulli A, Valvano MR, et al. Neoadjuvant chemoradiotherapy for patients with borderline resectable pancreatic cancer: a meta-analytical evaluation of prospective studies. *Jop* 2013;14:618-625. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24216547>.

537. Kim EJ, Ben-Josef E, Herman JM, et al. A multi-institutional phase 2 study of neoadjuvant gemcitabine and oxaliplatin with radiation therapy in patients with pancreatic cancer. *Cancer* 2013;119:2692-2700. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23720019>.

538. Landry J, Catalano PJ, Staley C, et al. Randomized phase II study of gemcitabine plus radiotherapy versus gemcitabine, 5-fluorouracil, and cisplatin followed by radiotherapy and 5-fluorouracil for patients with locally advanced, potentially resectable pancreatic adenocarcinoma. *J Surg Oncol* 2010;101:587-592. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20461765>.

539. Marti JL, Hochster HS, Hiotis SP, et al. Phase I/II trial of induction chemotherapy followed by concurrent chemoradiotherapy and surgery for locoregionally advanced pancreatic cancer. *Ann Surg Oncol* 2008;15:3521-3531. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18830756>.

540. Van Buren G, 2nd, Ramanathan RK, Krasinskas AM, et al. Phase II study of induction fixed-dose rate gemcitabine and bevacizumab followed by 30 Gy radiotherapy as preoperative treatment for potentially resectable pancreatic adenocarcinoma. *Ann Surg Oncol* 2013;20:3787-3793. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23904005>.

541. McClaine RJ, Lowy AM, Sussman JJ, et al. Neoadjuvant therapy may lead to successful surgical resection and improved survival in patients with borderline resectable pancreatic cancer. *HPB (Oxford)* 2010;12:73-79. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20495649>.

542. Stokes JB, Nolan NJ, Stelow EB, et al. Preoperative capecitabine and concurrent radiation for borderline resectable pancreatic cancer. *Ann Surg Oncol* 2011;18:619-627. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21213060>.

543. Laurence JM, Tran PD, Morarji K, et al. A systematic review and meta-analysis of survival and surgical outcomes following neoadjuvant chemoradiotherapy for pancreatic cancer. *J Gastrointest Surg* 2011;15:2059-2069. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21913045>.

544. Christians KK, Tsai S, Mahmoud A, et al. Neoadjuvant FOLFIRINOX for borderline resectable pancreas cancer: a new treatment paradigm? *Oncologist* 2014;19:266-274. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24569947>.

545. Tinchon C, Hubmann E, Pichler A, et al. Safety and efficacy of neoadjuvant FOLFIRINOX treatment in a series of patients with borderline resectable pancreatic ductal adenocarcinoma. *Acta Oncol* 2013;52:1231-1233. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23445338>.

546. Artinyan A, Anaya DA, McKenzie S, et al. Neoadjuvant therapy is associated with improved survival in resectable pancreatic adenocarcinoma. *Cancer* 2011;117:2044-2049. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21523715>.

547. Breslin TM, Hess KR, Harbison DB, et al. Neoadjuvant chemoradiotherapy for adenocarcinoma of the pancreas: treatment variables and survival duration. *Ann Surg Oncol* 2001;8:123-132. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11258776>.

548. Evans DB, Rich TA, Byrd DR, et al. Preoperative chemoradiation and pancreaticoduodenectomy for adenocarcinoma of the pancreas. *Arch Surg* 1992;127:1335-1339. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/1359851>.

549. Evans DB, Varadhachary GR, Crane CH, et al. Preoperative gemcitabine-based chemoradiation for patients with resectable adenocarcinoma of the pancreatic head. *J Clin Oncol* 2008;26:3496-3502. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18640930>.

550. Hoffman JP, Weese JL, Solin LJ, et al. A pilot study of preoperative chemoradiation for patients with localized adenocarcinoma of the pancreas. *Am J Surg* 1995;169:71-77. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7818001>.

551. Hoffman JP, Lipsitz S, Pisansky T, et al. Phase II trial of preoperative radiation therapy and chemotherapy for patients with localized, resectable adenocarcinoma of the pancreas: an Eastern Cooperative Oncology Group Study. *J Clin Oncol* 1998;16:317-323. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9440759>.

552. Palmer DH, Stocken DD, Hewitt H, et al. A randomized phase 2 trial of neoadjuvant chemotherapy in resectable pancreatic cancer: gemcitabine alone versus gemcitabine combined with cisplatin. *Ann Surg Oncol* 2007;14:2088-2096. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17453298>.

553. Spitz FR, Abbruzzese JL, Lee JE, et al. Preoperative and postoperative chemoradiation strategies in patients treated with pancreaticoduodenectomy for adenocarcinoma of the pancreas. *J Clin Oncol* 1997;15:928-937. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/9060530>.

554. Talamonti MS, Small W, Mulcahy MF, et al. A multi-institutional phase II trial of preoperative full-dose gemcitabine and concurrent radiation for patients with potentially resectable pancreatic carcinoma. *Ann Surg Oncol* 2006;13:150-158. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16418882>.

555. Abbott DE, Tzeng CW, Merkow RP, et al. The cost-effectiveness of neoadjuvant chemoradiation is superior to a surgery-first approach in the treatment of pancreatic head adenocarcinoma. *Ann Surg Oncol* 2013;20 Suppl 3:S500-508. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23397153>.
556. Palta M, Willett C, Czito B. Role of radiation therapy in patients with resectable pancreatic cancer. *Oncology (Williston Park)* 2011;25:715-721, 727. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21874833>.
557. Takahashi H, Ogawa H, Ohigashi H, et al. Preoperative chemoradiation reduces the risk of pancreatic fistula after distal pancreatectomy for pancreatic adenocarcinoma. *Surgery* 2011;150:547-556. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21621236>.
558. Andriulli A, Festa V, Botteri E, et al. Neoadjuvant/preoperative gemcitabine for patients with localized pancreatic cancer: a meta-analysis of prospective studies. *Ann Surg Oncol* 2012;19:1644-1662. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22012027>.
559. Chua TC, Saxena A. Preoperative chemoradiation followed by surgical resection for resectable pancreatic cancer: a review of current results. *Surg Oncol* 2011;20:e161-168. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21704510>.
560. Pingpank JF, Hoffman JP, Ross EA, et al. Effect of preoperative chemoradiotherapy on surgical margin status of resected adenocarcinoma of the head of the pancreas. *J Gastrointest Surg* 2001;5:121-130. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11331473>.
561. Golcher H, Brunner TB, Witzigmann H, et al. Neoadjuvant chemoradiation therapy with gemcitabine/cisplatin and surgery versus immediate surgery in resectable pancreatic cancer : Results of the first prospective randomized phase II trial. *Strahlenther Onkol* 2014. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25252602>.
562. Tachezy M, Gebauer F, Petersen C, et al. Sequential neoadjuvant chemoradiotherapy (CRT) followed by curative surgery vs. primary surgery alone for resectable, non-metastasized pancreatic adenocarcinoma: NEOPA- a randomized multicenter phase III study (NCT01900327, DRKS00003893, ISRCTN82191749). *BMC Cancer* 2014;14:411. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24906700>.
563. Furman MJ, Lambert LA, Sullivan ME, Whalen GF. Rational follow-up after curative cancer resection. *J Clin Oncol* 2013;31:1130-1133. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23358986>.
564. Tzeng CW, Fleming JB, Lee JE, et al. Yield of clinical and radiographic surveillance in patients with resected pancreatic adenocarcinoma following multimodal therapy. *HPB (Oxford)* 2012;14:365-372. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22568412>.
565. Tzeng CW, Abbott DE, Cantor SB, et al. Frequency and intensity of postoperative surveillance after curative treatment of pancreatic cancer: a cost-effectiveness analysis. *Ann Surg Oncol* 2013;20:2197-2203. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23408126>.
566. Witkowski ER, Smith JK, Ragulin-Coyne E, et al. Is it worth looking? Abdominal imaging after pancreatic cancer resection: a national study. *J Gastrointest Surg* 2012;16:121-128. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21972054>.
567. Tempero MA, Berlin J, Ducreux M, et al. Pancreatic cancer treatment and research: an international expert panel discussion. *Ann Oncol* 2011;22:1500-1506. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21199884>.
568. Katz MH, Wang H, Fleming JB, et al. Long-term survival after multidisciplinary management of resected pancreatic adenocarcinoma. *Ann Surg Oncol* 2009;16:836-847. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19194760>.

569. Meyers MO, Meszoely IM, Hoffman JP, et al. Is reporting of recurrence data important in pancreatic cancer? *Ann Surg Oncol* 2004;11:304-309. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14993026>.

570. Arnaoutakis GJ, Rangachari D, Laheru DA, et al. Pulmonary resection for isolated pancreatic adenocarcinoma metastasis: an analysis of outcomes and survival. *J Gastrointest Surg* 2011;15:1611-1617. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21725701>.

571. House MG, Choti MA. Palliative therapy for pancreatic/biliary cancer. *Surg Clin North Am* 2005;85:359-371. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15833477>.

572. Soderlund C, Linder S. Covered metal versus plastic stents for malignant common bile duct stenosis: a prospective, randomized, controlled trial. *Gastrointest Endosc* 2006;63:986-995. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16733114>.

573. Moss AC, Morris E, Mac Mathuna P. Palliative biliary stents for obstructing pancreatic carcinoma. *Cochrane Database Syst Rev* 2006:CD004200. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16625598>.

574. Kitano M, Yamashita Y, Tanaka K, et al. Covered self-expandable metal stents with an anti-migration system improve patency duration without increased complications compared with uncovered stents for distal biliary obstruction caused by pancreatic carcinoma: a randomized multicenter trial. *Am J Gastroenterol* 2013;108:1713-1722. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24042190>.

575. Maire F, Hammel P, Ponsot P, et al. Long-term outcome of biliary and duodenal stents in palliative treatment of patients with unresectable adenocarcinoma of the head of pancreas. *Am J Gastroenterol* 2006;101:735-742. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16635221>.

576. Lillemoe KD, Cameron JL, Hardacre JM, et al. Is prophylactic gastrojejunostomy indicated for unresectable periampullary cancer? A prospective randomized trial. *Ann Surg* 1999;230:322-328. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10493479>.

577. Van Heek NT, De Castro SM, van Eijck CH, et al. The need for a prophylactic gastrojejunostomy for unresectable periampullary cancer: a prospective randomized multicenter trial with special focus on assessment of quality of life. *Ann Surg* 2003;238:894-902; discussion 902-895. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14631226>.

578. Lillemoe KD, Cameron JL, Kaufman HS, et al. Chemical splanchnicectomy in patients with unresectable pancreatic cancer. A prospective randomized trial. *Ann Surg* 1993;217:447-455; discussion 456-447. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/7683868>.

579. Wyse JM, Carone M, Paquin SC, et al. Randomized, double-blind, controlled trial of early endoscopic ultrasound-guided celiac plexus neurolysis to prevent pain progression in patients with newly diagnosed, painful, inoperable pancreatic cancer. *J Clin Oncol* 2011;29:3541-3546. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21844506>.

580. Wong GY, Schroeder DR, Carns PE, et al. Effect of neurolytic celiac plexus block on pain relief, quality of life, and survival in patients with unresectable pancreatic cancer: a randomized controlled trial. *JAMA* 2004;291:1092-1099. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/14996778>.

581. Jeurnink SM, Polinder S, Steyerberg EW, et al. Cost comparison of gastrojejunostomy versus duodenal stent placement for malignant gastric outlet obstruction. *J Gastroenterol* 2010;45:537-543. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20033227>.

582. Jeurnink SM, Steyerberg EW, Hof G, et al. Gastrojejunostomy versus stent placement in patients with malignant gastric outlet obstruction: a comparison in 95 patients. *J Surg Oncol* 2007;96:389-396. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17474082>.



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583. Jeurnink SM, van Eijck CH, Steyerberg EW, et al. Stent versus gastrojejunostomy for the palliation of gastric outlet obstruction: a systematic review. *BMC Gastroenterol* 2007;7:18. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17559659>.

584. Gurusamy KS, Kumar S, Davidson BR. Prophylactic gastrojejunostomy for unresectable periampullary carcinoma. *Cochrane Database Syst Rev* 2013;2:CD008533. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23450583>.

585. Gao L, Yang YJ, Xu HY, et al. A randomized clinical trial of nerve block to manage end-stage pancreatic cancerous pain. *Tumour Biol* 2014;35:2297-2301. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24163058>.

586. Zhong W, Yu Z, Zeng JX, et al. Celiac plexus block for treatment of pain associated with pancreatic cancer: a meta-analysis. *Pain Pract* 2014;14:43-51. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23682788>.

587. Lavu H, Lengel HB, Sell NM, et al. A prospective, randomized, double-blind, placebo controlled trial on the efficacy of ethanol celiac plexus neurolysis in patients with operable pancreatic and periampullary adenocarcinoma. *J Am Coll Surg* 2015;220:497-508. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25667135>.

588. Dominguez-Munoz JE. Pancreatic enzyme therapy for pancreatic exocrine insufficiency. *Curr Gastroenterol Rep* 2007;9:116-122. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17418056>.

589. Keller J, Layer P. Human pancreatic exocrine response to nutrients in health and disease. *Gut* 2005;54 Suppl 6:vi1-28. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/15951527>.

590. Sikkens EC, Cahen DL, Kuipers EJ, Bruno MJ. Pancreatic enzyme replacement therapy in chronic pancreatitis. *Best Pract Res Clin Gastroenterol* 2010;24:337-347. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20510833>.

591. Dominguez-Munoz JE. Pancreatic exocrine insufficiency: diagnosis and treatment. *J Gastroenterol Hepatol* 2011;26 Suppl 2:12-16. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21323992>.

592. Lemaire E, O'Toole D, Sauvanet A, et al. Functional and morphological changes in the pancreatic remnant following pancreaticoduodenectomy with pancreaticogastric anastomosis. *Br J Surg* 2000;87:434-438. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/10759738>.

593. Epstein AS, O'Reilly EM. Exocrine pancreas cancer and thromboembolic events: a systematic literature review. *J Natl Compr Canc Netw* 2012;10:835-846. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22773799>.

594. Khorana AA, Francis CW, Culakova E, et al. Thromboembolism in hospitalized neutropenic cancer patients. *J Clin Oncol* 2006;24:484-490. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/16421425>.

595. Lee AYY, Levine MN, Baker RI, et al. Low-molecular-weight heparin versus a coumarin for the prevention of recurrent venous thromboembolism in patients with cancer. *N Engl J Med* 2003;349:146-153. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12853587>.

596. Pelzer U, Opitz B, Deuschinoff G, et al. Efficacy of prophylactic low-molecular weight heparin for ambulatory patients with advanced pancreatic cancer: outcomes from the CONKO-004 trial. *J Clin Oncol* 2015;33:2028-2034. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/25987694>.

597. Riess H, Pelzer U, Deuschinoff G, et al. A prospective, randomized trial of chemotherapy with or without the low molecular weight heparin (LMWH) enoxaparin in patients (pts) with advanced pancreatic cancer (APC): Results of the CONKO 004 trial [abstract]. *J Clin Oncol* 2009;27(suppl):LBA4506. Available at: <http://meeting.ascopubs.org/cgi/content/abstract/27/18S/LBA4506?sid=e598f786-51a5-42d1-82a4-08d6f1163f76>.



598. Boyd AD, Brown D, Henrickson C, et al. Screening for depression, sleep-related disturbances, and anxiety in patients with adenocarcinoma of the pancreas: a preliminary study. *ScientificWorldJournal* 2012;2012:650707. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/22666142>.

599. Turaga KK, Malafa MP, Jacobsen PB, et al. Suicide in patients with pancreatic cancer. *Cancer* 2011;117:642-647. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20824626>.

600. Philip PA, Mooney M, Jaffe D, et al. Consensus report of the national cancer institute clinical trials planning meeting on pancreas cancer treatment. *J Clin Oncol* 2009;27:5660-5669. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19858397>.

601. Van Laethem JL, Verslype C, Iovanna JL, et al. New strategies and designs in pancreatic cancer research: consensus guidelines report from a European expert panel. *Ann Oncol* 2012;23:570-576. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21810728>.

602. Tempero MA, Klimstra D, Berlin J, et al. Changing the way we do business: recommendations to accelerate biomarker development in pancreatic cancer. *Clin Cancer Res* 2013;19:538-540. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23344262>.

603. Ellis LM, Bernstein DS, Voest EE, et al. American society of clinical oncology perspective: raising the bar for clinical trials by defining clinically meaningful outcomes. *J Clin Oncol* 2014;32:1277-1280. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24638016>.

604. Philip PA, Chansky K, LeBlanc M, et al. Historical controls for metastatic pancreatic cancer: benchmarks for planning and analyzing single-arm phase II trials. *Clin Cancer Res* 2014;20:4176-4185. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/24914040>.

605. Varadhachary GR, Evans DB. Rational study endpoint(s) for preoperative trials in pancreatic cancer: pathologic response rate, margin negative resection, overall survival or 'all of the above'? *Ann*

Surg Oncol 2013;20:3712-3714. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/23943023>.

606. Bao Z, Cao C, Geng X, et al. Effectiveness and safety of poly (ADP-ribose) polymerase inhibitors in cancer therapy: A systematic review and meta-analysis. *Oncotarget* 2015. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/26399274>.

607. Kaufman B, Shapira-Frommer R, Schmutzler RK, et al. Olaparib monotherapy in patients with advanced cancer and a germline BRCA1/2 mutation. *J Clin Oncol* 2015;33:244-250. Available at: <https://www.ncbi.nlm.nih.gov/pubmed/25366685>.

608. Domchek SM, Hendifar AE, McWilliams RR, et al. RUCAPANC: An open-label, phase 2 trial of the PARP inhibitor rucaparib in patients (pts) with pancreatic cancer (PC) and a known deleterious germline or somatic BRCA mutation. *ASCO Meeting Abstracts* 2016;34:4110. Available at: http://meeting.ascopubs.org/cgi/content/abstract/34/15_suppl/4110.

609. Pogue-Geile KL, Chen R, Bronner MP, et al. Palladin mutation causes familial pancreatic cancer and suggests a new cancer mechanism. *PLoS Med* 2006;3:e516. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/17194196>.

610. Wayne JD, Abdalla EK, Wolff RA, et al. Localized adenocarcinoma of the pancreas: the rationale for preoperative chemoradiation. *Oncologist* 2002;7:34-45. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/11854545>.