



National
Comprehensive
Cancer
Network®

NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)

Pancreatic Adenocarcinoma

Version 2.2015

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Pancreatic Adenocarcinoma

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Pancreatic Adenocarcinoma Panel: Imaging Subcommittee

NCCN gratefully acknowledges the following subcommittee members for their contributions during the update of the Principles of Diagnosis, Imaging and Staging (PANC-A) and Criteria Defining Resectability Status (PANC-B) in Version 1.2015 of the NCCN Guidelines for Pancreatic Adenocarcinoma:

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[NCCN Pancreatic Adenocarcinoma Panel Members](#)

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[Introduction](#)

[Clinical Suspicion of Pancreatic Cancer or Evidence of Dilated Pancreatic and/or Bile Duct \(PANC-1\)](#)

[No Metastatic Disease on Physical Exam and by Imaging \(PANC-2\)](#)

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

[American Joint Committee on Cancer \(AJCC\) TNM Staging of Pancreatic Cancer \(2010\) \(ST-1\)](#)

Clinical Trials: NCCN believes that the best management for any cancer patient 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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Updates in Version 2.2015 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 1.2015 include:

[PANC-3](#)

- Recommendations were clarified for the use of celiac plexus neurolysis when cancer is found to be unresectable at surgery: "... ± celiac plexus neurolysis if pain when indicated by pain (category 2B if no pain)." (Also for PANC-4 and PANC-5)

Updates in Version 1.2015 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 2.2014 include:

[General](#)

- "Duodenal bypass" was changed to "gastrojejunostomy" throughout.
- "Open celiac plexus block" was changed to "celiac plexus neurolysis" throughout.
- "Short metal stent" and "stent" were changed to "self-expanding metal stent" throughout.
- "Salvage therapy" was changed to "second-line therapy" throughout.

[Introduction](#)

- The introduction statement was clarified: "...at a high-volume center with reference to use of appropriate imaging studies."

[PANC-1](#)

- Under workup, MRI was removed: "Pancreatic protocol CT or MRI (See PANC-A)."
- No mass in pancreas on imaging, no metastatic disease: EUS is now listed as a separate and "preferred" option over MRCP or ERCP.

[PANC-2](#)

- Footnote "g" was added: "Self-expanding metal stent as clinically indicated in patients with select comorbidities or when surgery may be delayed. (See Discussion)."

[PANC-3](#)

- Footnote "i" was revised: "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." (Also on PANC-4)

[PANC-6](#)

- Footnote "m" was revised: "... Adjuvant treatment should be administered to patients who have not had neoadjuvant chemotherapy and who have adequately recovered from surgery; treatment should be initiated within 4- & 12 weeks...."

[PANC-8](#)

- Under treatment, "fluoropyrimidine + oxaliplatin (category 2B)" was added for consistency with the acceptable chemotherapy combinations listed on PANC-G (1 of 3) for patients with good performance status and locally advanced or metastatic disease. (Also on PANC-9)
- Footnote "u" was revised: "Based 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.)* (Also for footnote "a" on PANC-F 2 of 6)

[PANC-9](#)

- For good performance status, the treatment options were separated into two groups, "Preferred" and "Other options." Preferred options are: "Clinical trial, or FOLFIRINOX (category 1), or Gemcitabine + albumin-bound paclitaxel (category 1)."

[PANC-10](#)

- Footnote "z" was added: "For more information about the treatment of isolated pulmonary metastases, see Discussion."

[Continued on next page](#)

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Updates in Version 1.2015 of the NCCN Guidelines for Pancreatic Adenocarcinoma from Version 2.2014 include:

PANC-A

- This section was significantly revised and expanded.

PANC-B

- This section was significantly revised and put into table format.

PANC-E

- Gastric outlet obstruction, under poor performance status the second sub-bullet was revised: “*Venting percutaneous endoscopic gastrostomy (PEG) tube for gastric decompression.*”
- Fifth bullet was revised: “Pancreatic exocrine insufficiency (~~inadequate production of digestive enzymes~~).”

PANC-F (2 of 6)

- Under adjuvant therapy, the 3rd sub-bullet was revised: “Gemcitabine or bolus 5-FU/leucovorin or *continuous infusion 5-FU.*”

PANC-F (3 of 6)

- Fourth bullet was revised: “IORT is delivered...The role of IORT for ~~unresectable and resectable cases~~ is controversial and should only be performed at specialized centers in ~~well selected cases~~. It is *sometimes* ~~ideally~~ used in cases where surgical resection may result in close or involved margins.

PANC-G (1 of 3)

- Under Metastatic, the last bullet was revised: “Second-line chemotherapy may consist of gemcitabine-based therapy for those previously treated with fluoropyrimidine-based therapy, and fluoropyrimidine-based therapy for those previously treated with gemcitabine-based therapy. ~~Results of the CONKO 003 trial demonstrated a significant improvement in overall survival with the addition of oxaliplatin to 5-FU/leucovorin.~~”

PANC- G (2 of 3)

- Under Adjuvant, the last bullet was revised: “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. Subsequent therapy may consist of gemcitabine or gemcitabine-based combination therapy for patients previously treated with fluoropyrimidine-based therapy, or fluoropyrimidine-based therapy (eg, 5-FU/leucovorin/oxaliplatin⁷ or CapeOx)⁸ for patients previously treated with gemcitabine-based therapy.*”
- Neoadjuvant bullet was revised: “*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. Although there is insufficient evidence to recommend specific neoadjuvant regimens, most published neoadjuvant studies that were done prior to the introduction of more effective combination chemotherapy incorporated chemoradiation. Studies of these more effective regimens (ie, FOLFIRINOX or gemcitabine and albumin-bound paclitaxel) without chemoradiation are in progress.*”

MS-1

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

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INTRODUCTION

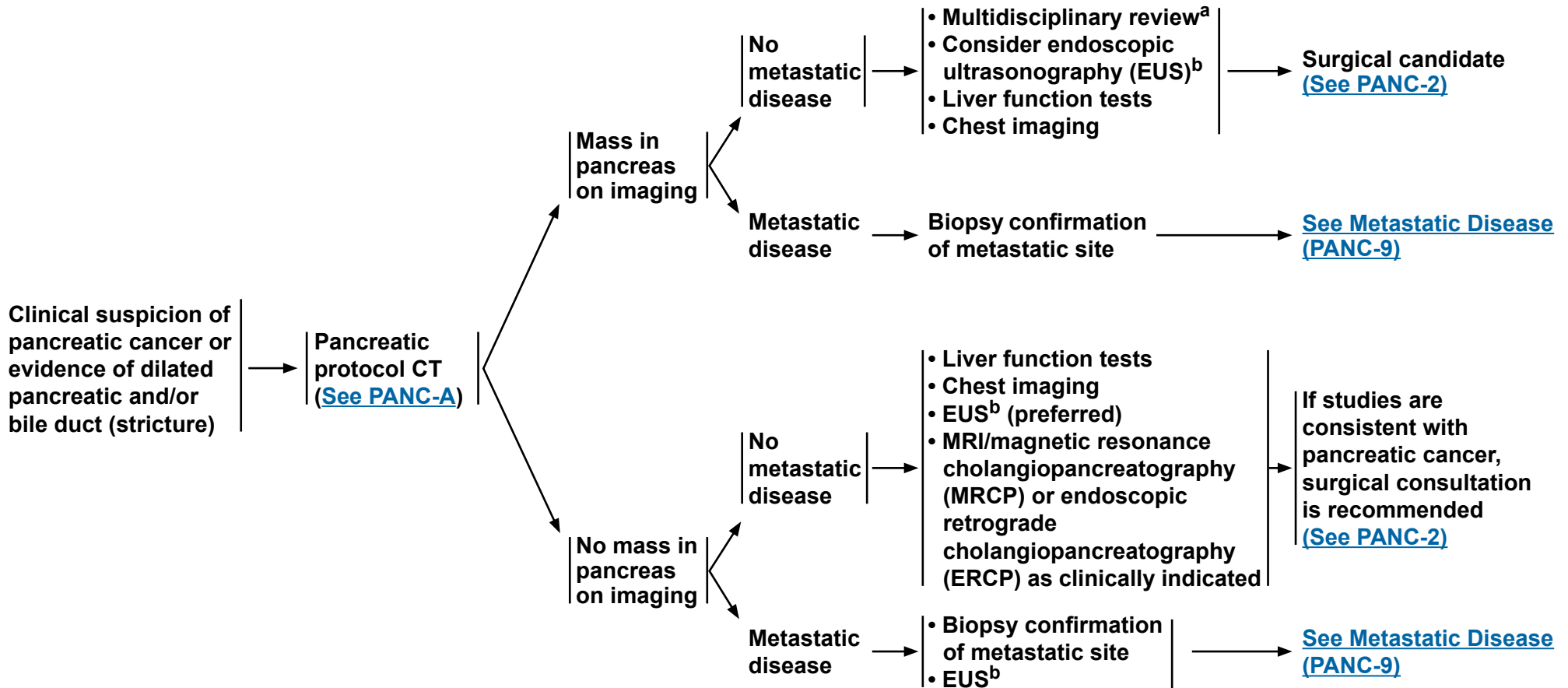
Decisions about diagnostic management and resectability should involve multidisciplinary consultation at a high-volume center with use of appropriate imaging studies.

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**CLINICAL
PRESENTATION**

WORKUP



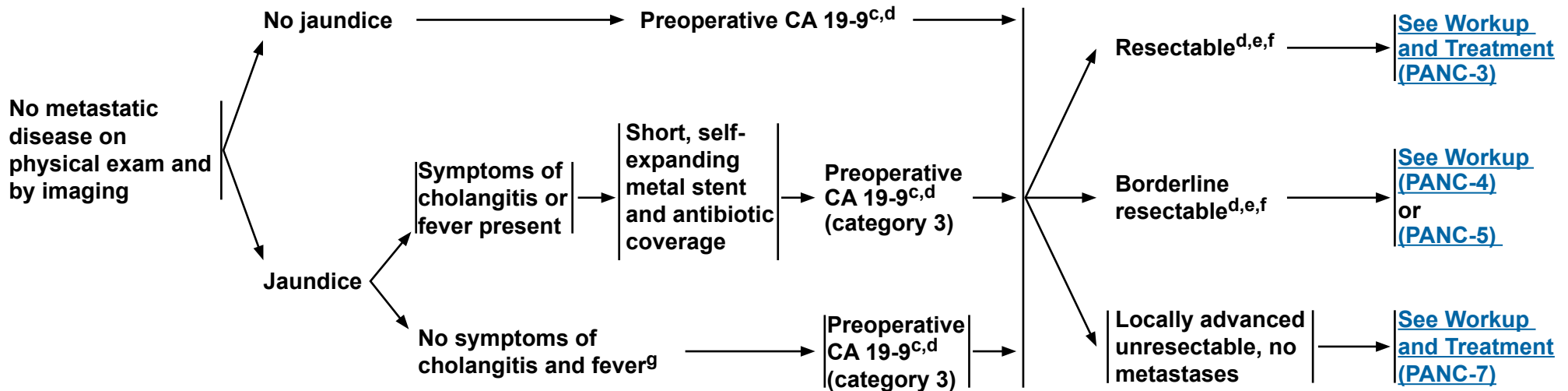
^aMultidisciplinary review should ideally involve expertise from diagnostic imaging, interventional endoscopy, medical oncology, radiation oncology, surgery, and pathology.

^bEUS-FNA if clinically indicated.

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CLINICAL PRESENTATION

WORKUP



^cElevated 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](#))

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

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

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

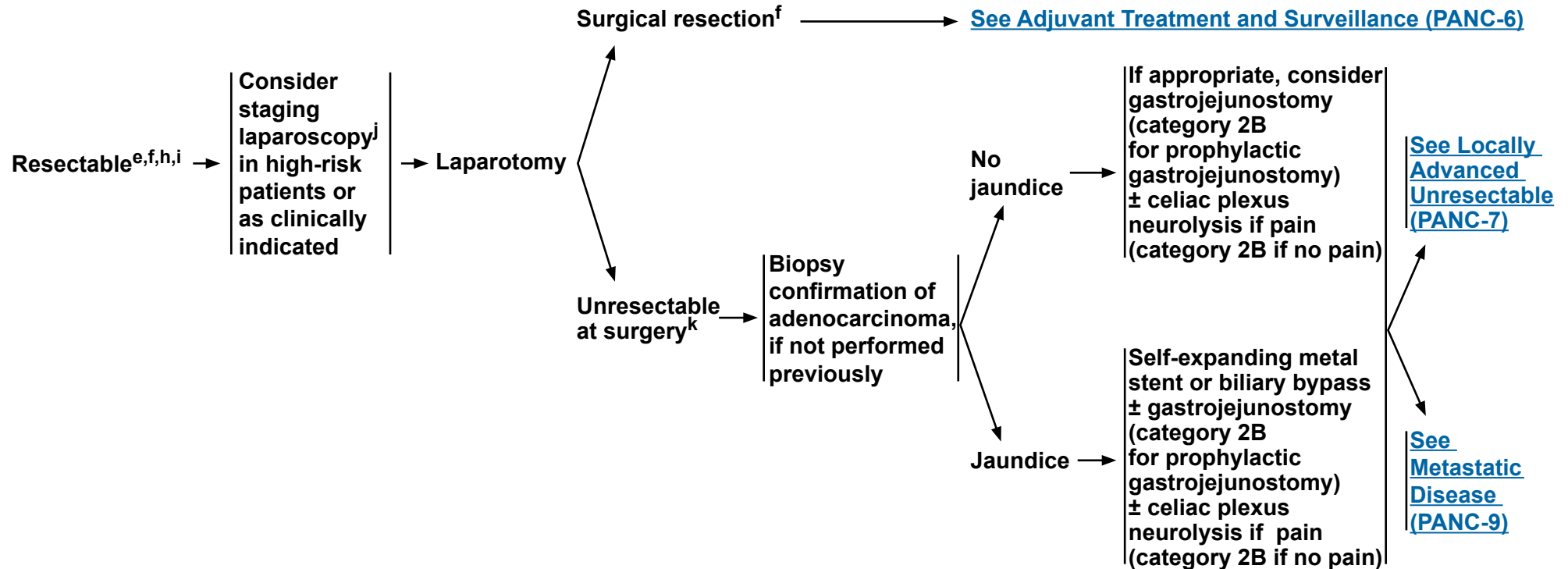
^gSelf-expanding metal stent as clinically indicated in patients with select comorbidities or when surgery may be delayed. ([See Discussion](#))

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RESECTABLE

WORKUP

TREATMENT



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

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

^hIn 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.

ⁱThere 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. Performing surgery with a high likelihood of a positive margin is not recommended.

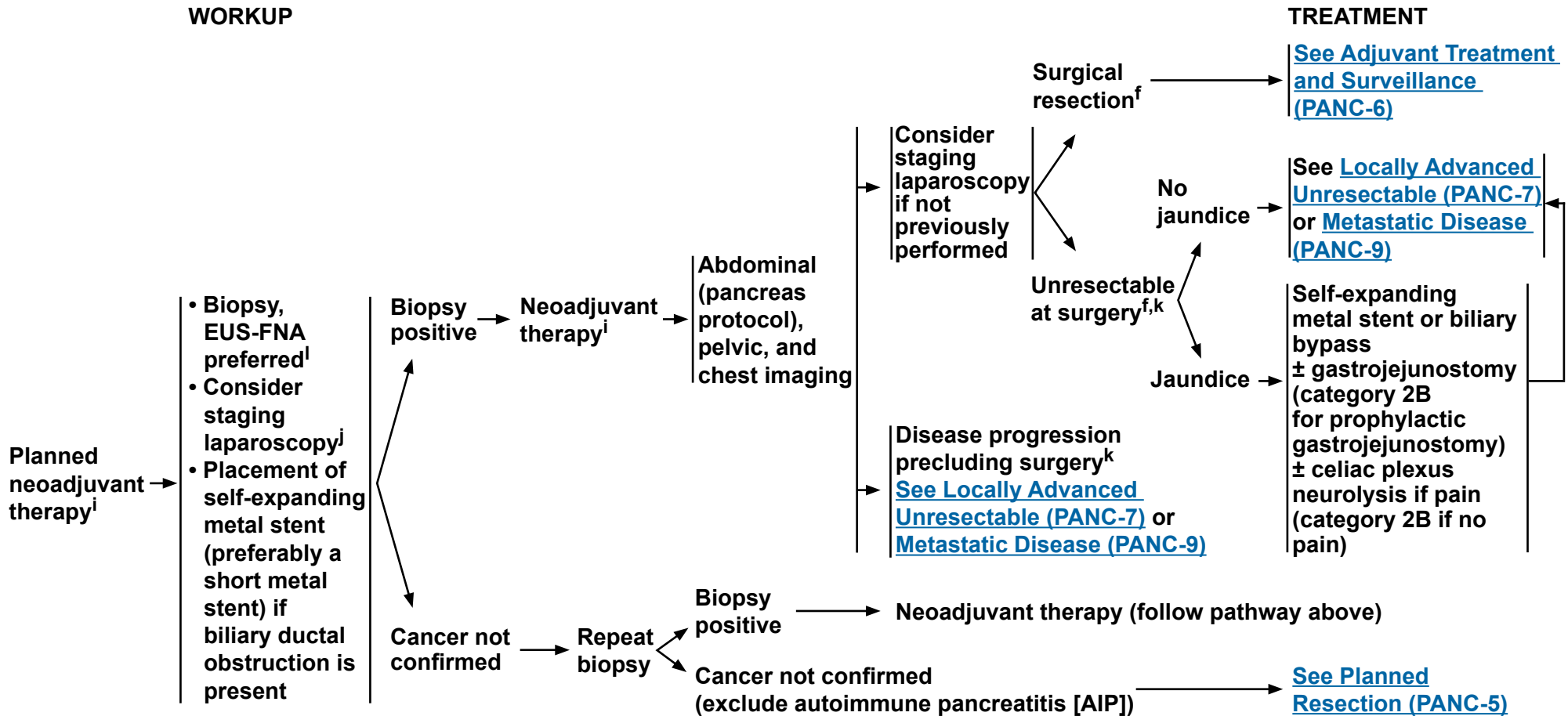
^jSee [Principles of Diagnosis, Imaging, and Staging #8 \(PANC-A\)](#).

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

Note: All recommendations are category 2A unless otherwise indicated.

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BORDERLINE RESECTABLE^{d,e} NO METASTASES, PLANNED NEOADJUVANT THERAPY WORKUP



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

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

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

ⁱThere 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. Performing surgery with a high likelihood of a positive margin is not recommended.

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

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

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

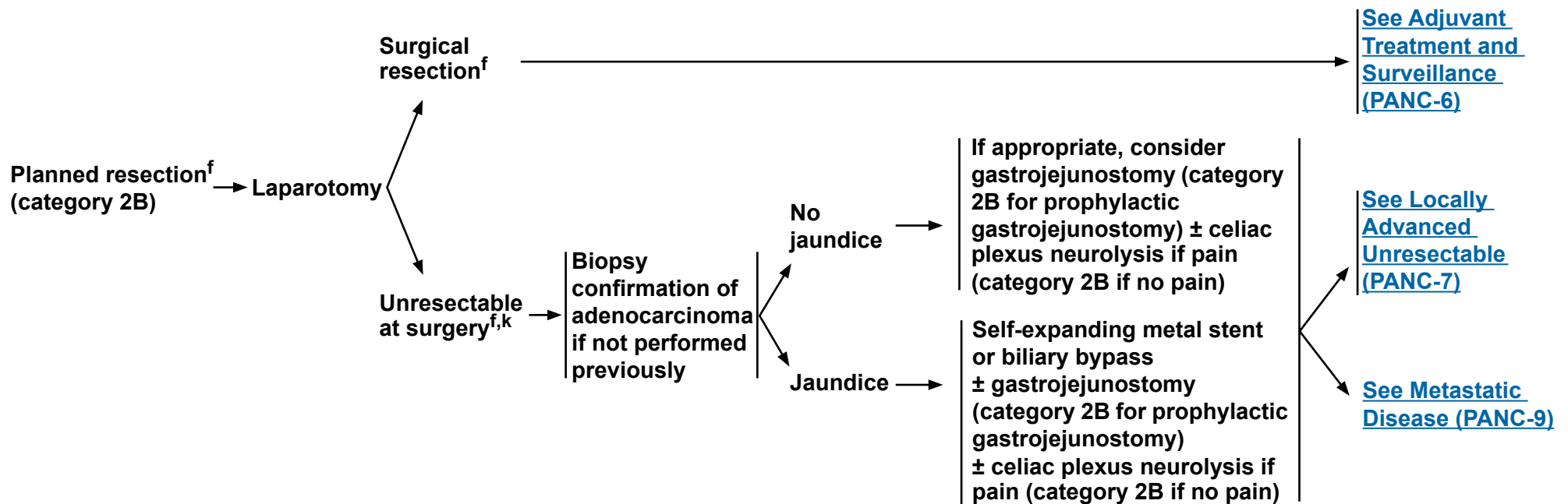
Note: All recommendations are category 2A unless otherwise indicated.

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BORDERLINE RESECTABLE^{d,e} NO METASTASES, PLANNED RESECTION

WORKUP

TREATMENT



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

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

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

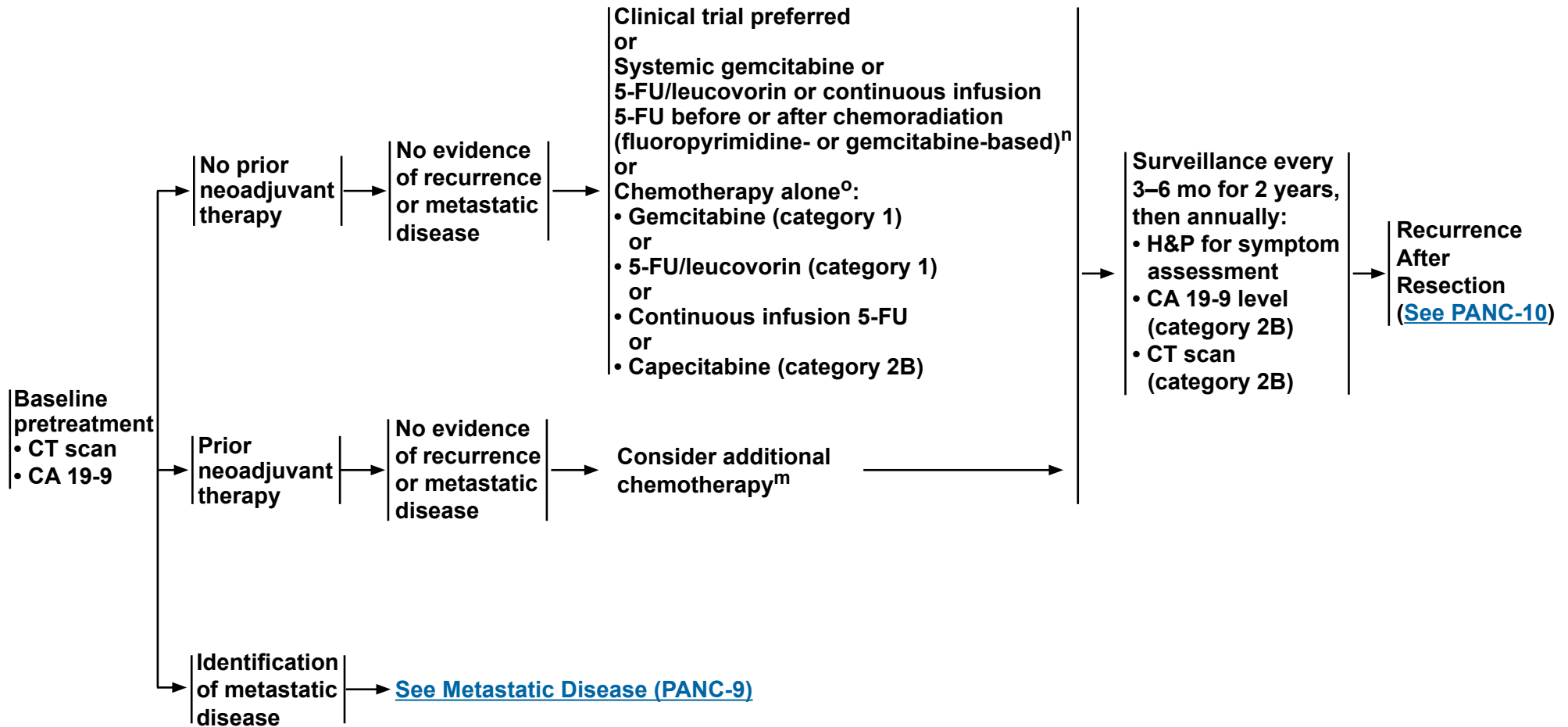
^kSee Principles of Palliation and Supportive Care (PANC-E).

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POSTOPERATIVE ADJUVANT TREATMENT^m

SURVEILLANCE



^mPatients who have received neoadjuvant chemoradiation or chemotherapy may be candidates for additional chemotherapy following surgery and multidisciplinary review. Adjuvant 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.

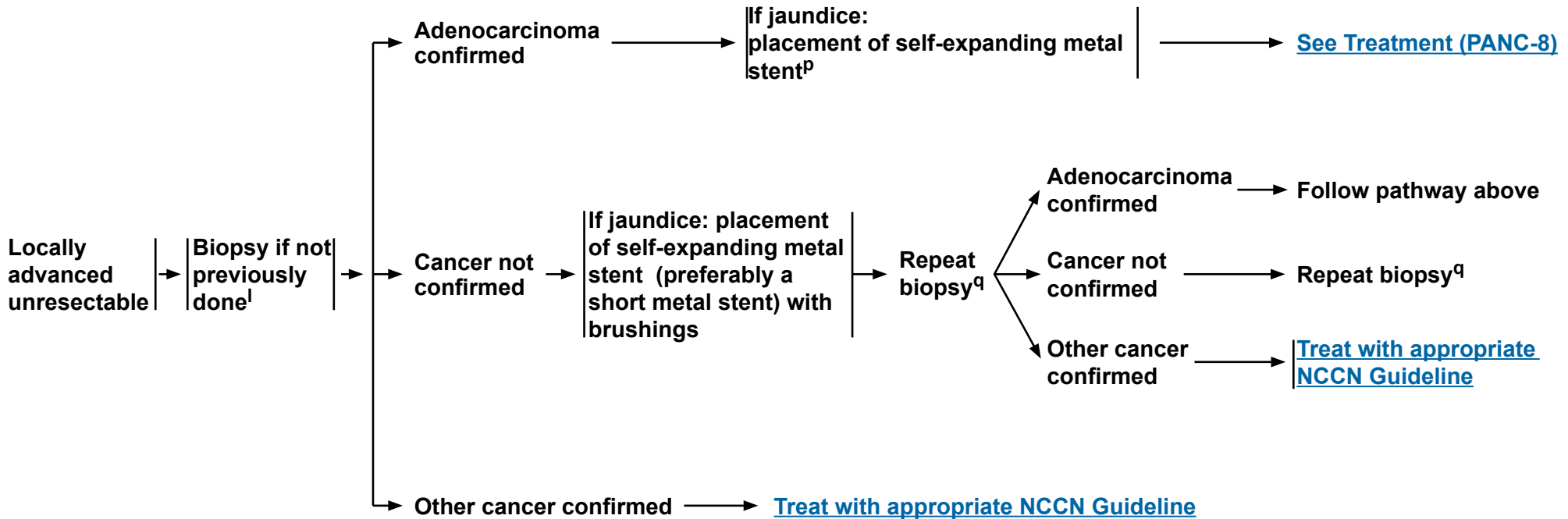
ⁿSee [Principles of Radiation Therapy \(PANC-F\)](#).

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

Note: All recommendations are category 2A unless otherwise indicated.
Clinical Trials: NCCN believes that the best management of any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.

LOCALLY ADVANCED UNRESECTABLE

WORKUP



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

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

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

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**LOCALLY
ADVANCED
UNRESECTABLE**

TREATMENT

SECOND-LINE THERAPY^W

Good
performance
status^r

Chemotherapy:

- Clinical trial preferred
or
- FOLFIRINOX^{o,x}
or
- Gemcitabine^o
or
- Gemcitabine + albumin-bound paclitaxel^{o,x} or other gemcitabine-based combination therapy^o
or
- Capecitabine^o or continuous infusion 5-FU^o (category 2B)
or
- Fluoropyrimidine + oxaliplatin^o (category 2B)

Chemoradiation in selected patients (locally advanced without systemic metastases), preferably following an adequate course of chemotherapy^{n,s,t,u}

Good
performance
status^{r,v}

- Clinical trial (preferred)
or
- Fluoropyrimidine-based chemotherapy if previously treated with gemcitabine-based therapy^o
or
- Gemcitabine-based therapy if previously treated with fluoropyrimidine-based therapy^o
or
- Chemoradiation if not previously given and if primary site is the sole site of progressionⁿ

Poor
performance
status

**Palliative
and
best
supportive
care^k**

Poor
performance
status

**Gemcitabine^o (category 1)
or
Palliative and best supportive care^{k,n}**

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

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

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

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

^sLaparoscopy as indicated to evaluate distant disease.

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

^uBased 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.)

^vPatients with a significant response to therapy may be considered for surgical resection.

^wBest reserved for patients who maintain a good performance status.

^xThe 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.

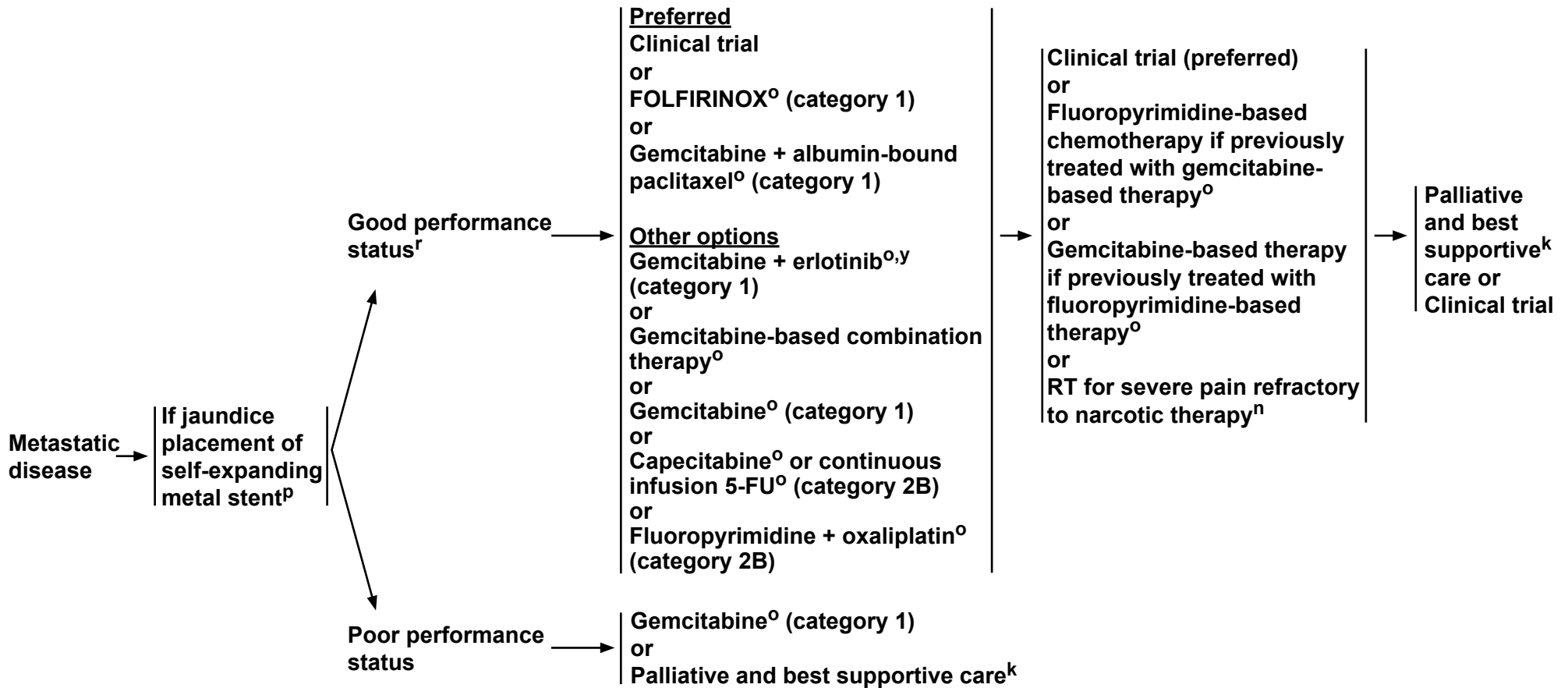
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METASTATIC DISEASE

TREATMENT

SECOND-LINE THERAPY^w



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

ⁿSee Principles of Radiation Therapy (PANC-F).

^oSee Principles of Chemotherapy (PANC-G).

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

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

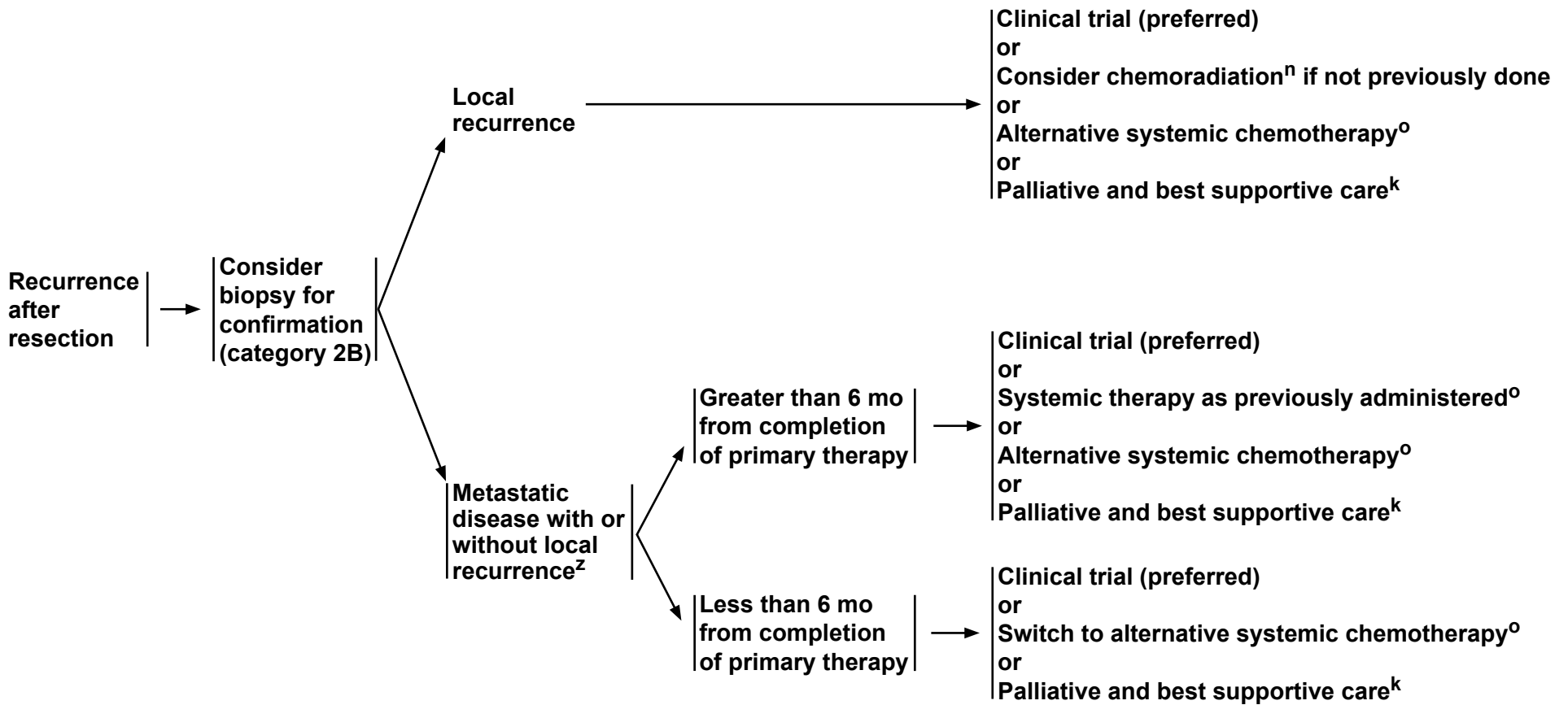
^wBest reserved for patients who maintain a good performance status.

^yAlthough 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^W



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

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

^OSee Principles of Chemotherapy (PANC-G).

^WBest reserved for patients who maintain a good performance status.

^ZFor 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 Protocol, PANC-A (3 of 4).**
 - **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 Pancreas Protocol, PANC-A (4 of 4).**
 - **MR cholangiopancreatography 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**

[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. *Gastroenterology*. 2014 Jan; 146 (1):291-304 and *Radiology*. 2014 Jan; 270 (1):248-60.

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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-risk* 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 risk* for disseminated disease.
- #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.

[Continued on next page](#)

*Indicators 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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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 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. Gastroenterology. 2014 Jan; 146 (1):291-304.

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PRINCIPLES OF DIAGNOSIS, IMAGING, AND STAGING

MRI Pancreatic Adenocarcinoma Protocol²

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 (gadolinium³) 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

²Sheridan MB1, 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.

³Unenhanced 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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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. Gastroenterology. 2014 Jan; 146 (1):291-304.

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 SMVs 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}
- Utilization of radical resections is associated with an increase in blood loss, transfusion requirements, operating time, length of stay, and whether morbidity/mortality remains acceptable.^{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, Nagorney DM, Farnell MB. 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.

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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.
- ▶ Frozen section analysis of the pancreatic neck and bile duct is recommended. 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 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.
- Margins 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.

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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.
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- 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, Kinoshita T, Ochiai A, Shimizu N. 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**
 - ▶ 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
- **Depression, pain, and malnutrition**
 - ▶ Formal Palliative Medicine Service evaluation when appropriate ([See NCCN Guidelines for Supportive Care](#))
 - ▶ Nutritional evaluation when appropriate.
- **Pancreatic exocrine insufficiency**
 - ▶ Pancreatic enzyme replacement
- **Thrombembolic disease**
 - ▶ Low-molecular-weight heparin preferred over warfarin

^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.

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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, others 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/cealic 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:

- Treatment options following pancreaticoduodenectomy or distal pancreatectomy include:

- ▶ Upfront fluoropyrimidine- (CI 5-FU or capecitabine) or gemcitabine-based chemoradiation followed by maintenance 5-FU or gemcitabine.¹³
 - ▶ 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-FU¹⁵
 - ▶ 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.

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^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.)

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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 set-up 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 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 set-up 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 set-up 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 dose-volume histogram (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.

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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 ^b	Adjuvant/Resected Recommendations ^c
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.

^bAdapted from RTOG 0936 (3-D conformal, 1.8-50.5) and RTOG 1102 (IMRT, 2.2 to 55 Gy)

^cAdapted from RTOG 0848 (3-D or IMRT)

[Continued on next page](#)

Note: All recommendations are category 2A unless otherwise indicated.

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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

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Note: All recommendations are category 2A unless otherwise indicated.

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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 (especially for patients with possible hereditary cancers)
 - ▶ 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/minute) 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 gemcitabine-based therapy for those previously treated with fluoropyrimidine-based therapy, and of 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. (Hammel 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.)

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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.

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)
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Note: All recommendations are category 2A unless otherwise indicated.

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



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)

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

* This also includes the “PanInIII” classification.

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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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Overview

During the year 2014 in the United States, an estimated 46,420 people will be diagnosed with pancreatic cancer, and approximately 39,590 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 Its peak incidence occurs in the seventh and eighth decades of life.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 recent 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 28, 2013 and July 28, 2014, 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 An increased body mass index (BMI) is also associated with an increased risk for pancreatic cancer.¹⁷⁻²⁰ There is also some evidence that increased consumption of red/processed meat and dairy products is associated with an elevation in pancreatic cancer risk,^{21,22} although other studies have failed to identify dietary risk factors for the disease.^{15,23,24} Occupational exposure to chemicals such as beta-naphthylamine and benzidine is associated with increased risk for pancreatic cancer,²⁵ as is heavy alcohol consumption.^{11,13,17,26} Recent data also suggest that low plasma 25-hydroxyvitamin D levels may increase the risk for pancreatic cancer.²⁷ Chronic pancreatitis has also been identified as a risk factor for pancreatic cancer,²⁸⁻³¹ with one study demonstrating a 7.2-fold increased risk for pancreatic cancer for patients with a history of pancreatitis.³² 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. Numerous studies have shown an association between new-onset non-insulin-dependent diabetes and the development of pancreatic cancer,³³⁻³⁷ especially in those who are

elderly, have a lower BMI, experience weight loss, or do not have a family history of diabetes.³⁸ 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.³⁹ 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.³³

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.⁴⁰ However, certain risk factors such as obesity, associated with both diabetes and pancreatic cancer, may confound these analyses.⁴¹ Furthermore, the use of diabetic medications has been reported to alter pancreatic cancer risk.⁴² The use of insulin or sulfonylureas has been found to be associated with an increased risk for pancreatic cancer.⁴³⁻⁴⁵ On the other hand, metformin may be associated with a reduced risk for pancreatic and other cancers.⁴³⁻⁴⁸

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; $P = .009$).⁴⁹ 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; $P < 0.001$).³⁶ 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.⁵⁰ After multivariable-adjustment, mortality was significantly higher in participants with diabetes compared to those without (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.^{15,51-54} The genetic basis of this inherited predisposition is not known in most cases; 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.⁵⁵⁻⁵⁷ These individuals also have a highly elevated risk for developing pancreatic cancer, reported to be increased by as much as 132-fold.^{58,59} Furthermore, *STK11* undergoes somatic mutation in approximately 5% of pancreatic cancers.⁶⁰

As with non-hereditary forms of pancreatitis, familial pancreatitis is also associated with an increased risk for pancreatic cancer.⁶¹ Several genes are associated with the familial form of pancreatitis, including *PRSS1*, *SPINK1*, and *CFTR*.⁶² The increased risk for the development of pancreatic cancer in these individuals is estimated to be 26-fold to as high as 87-fold.^{29,63-65}

Familial Malignant Melanoma syndrome (also known as Melanoma-Pancreatic Cancer syndrome or Familial Atypical Multiple Mole

Melanoma syndrome [FAMMM]) is caused by germline mutation of the *CDKN2A* (p16INK4a/p14ARF) gene.⁶⁶ This syndrome is associated with a 20-fold to 47-fold increased risk for pancreatic cancer.^{67,68} In addition, patients with Melanoma-Pancreatic Cancer syndrome may experience an earlier onset of pancreatic cancer than the general population.⁶⁹ In an unselected series of 225 patients with pancreatic cancer in Italy, 5.7% had mutations in *CDKN2A*.⁷⁰

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*).⁷¹⁻⁷⁶ Patients with Lynch syndrome also have an estimated 9- to 11-fold elevated risk for pancreatic cancer.^{77,78}

An excess of pancreatic cancer is also seen in families with hereditary Breast-Ovarian Cancer syndrome, harboring *BRCA1* and *BRCA2* (breast cancer susceptibility gene-1 and -2) mutations, although the link with *BRCA2* is better established.⁷⁹⁻⁸⁴ In a study of 187 Ashkenazi Jewish patients who had resections for pancreatic cancer, mutations in *BRCA1* and *BRCA2* were identified in 5.5% of patients.⁸¹ Other studies of unselected patients with pancreatic cancer have detected *BRCA* mutations at a frequency of 4% to 7%.⁸⁵ The risk of pancreatic cancer is elevated 2- to 6-fold in these patients, and the age of onset is younger than average in the general population.^{79,83,84}

BRCA1 and *BRCA2* are 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.⁸⁶⁻⁸⁸ Additionally, whole-genome sequencing recently allowed for the identification of germline mutations in *ATM*, a DNA damage response

gene, in 2 kindreds with familial pancreatic cancer.⁸⁹ Further analyses then revealed *ATM* mutations in 4 of 166 individuals with familial pancreatic cancer.

As many as 80% of patients with a family history of pancreatic cancer have no known genetic cause.⁵¹ 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.⁹⁰

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.⁵⁴ 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.⁹¹⁻⁹³ 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%.⁹⁴ The risk of malignancy in MCNs is <15%.⁹⁴

An international group of experts has established guidelines for the management of pancreatic IPMNs and MCNs,⁹⁴ as has a European group.⁹⁵ The international group strongly recommends resection in fit patients with main duct IPMNs.⁹⁴ For branch-duct IPMNs, surveillance is considered an appropriate option in older or unfit patients 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.⁹⁴ 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.⁹⁴ The European group gives similar recommendations.⁹⁵

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.⁹⁶ 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 recently reported results of their CAPS3 study, in which 225 asymptomatic high-risk individuals were independently (in a blinded manner) screened once with CT, MRI, and EUS.⁹⁷ 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 with annual MRI were

recently published.⁹⁸ 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. 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,⁹⁹ while a German study used EUS plus MRI/magnetic resonance cholangiopancreatography (MRCP) in a similar high-risk population.¹⁰⁰ 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.¹⁰¹⁻¹⁰⁴ 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%.¹⁰⁵ 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.¹⁰⁶

An international CAPS Consortium summit with 49 multidisciplinary experts was held in 2011 to develop consensus guidelines for pancreatic cancer screening.¹⁰⁷ 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.¹⁰⁸ 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.¹⁰⁹ 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.¹¹⁰ 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.^{110,111} Recent 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).¹¹¹

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.^{108,109,112} Studies have shown that 70% to 85% of patients determined by CT imaging to have resectable tumors were able to undergo resection.^{108,113-117} 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.¹¹⁶

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.¹¹⁸

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.^{119,120}

Recently, a multidisciplinary expert consensus group defined standardized language for the reporting of imaging results.¹⁰⁹ 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 preferred by the panel.

Endoscopic Ultrasound

NCCN Member Institutions vary in the use of additional staging technologies, such as EUS. 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.¹²¹⁻¹²⁴ In particular, EUS may provide assessment of certain types of vascular invasion.^{125,126} 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.¹²⁷ 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.¹²⁸ 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.¹²⁹ 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.¹³⁰ 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.¹³¹

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.¹³² 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.^{133,134} 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.¹³⁵⁻¹³⁷ 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,¹³⁶ 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).¹³⁸ 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.^{139,140} In a recent 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.¹⁴¹ 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

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. The panel considers positive cytology from washings obtained at laparoscopy or laparotomy to be equivalent to M1 disease.¹⁴²

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.¹⁴³⁻¹⁴⁵ 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.¹⁴⁶ In contrast, 13% of cases that were classified as benign were actually malignant. In rare cases when an

EUS-FNA cannot be obtained from a borderline resectable or unresectable patient, other acceptable methods of biopsy exist. For instance, intraductal biopsies can be obtained via endoscopic cholangioscopy.¹⁴⁷ A percutaneous approach¹⁴⁴ or a laparoscopic biopsy¹⁴⁸ 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 patients 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 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.

Differential Diagnoses

Chronic pancreatitis and other benign conditions are possible differential diagnoses of patients suspected of having pancreatic cancer.¹⁴⁹⁻¹⁵³ 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.^{151,154-156} 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.¹⁵⁵ 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.^{157,158} 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.¹⁵⁷⁻¹⁶⁰

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.¹⁶¹ 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.¹⁶² 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.

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 to personalize therapy in this difficult disease, and they emphasize the need for collection and sharing of tissue to help accelerate the discovery of predictive and prognostic biomarkers (see *Future Clinical Trials: Recommendations for Design*, below).

CA 19-9

The best validated and most clinically useful biomarker 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).¹⁶³ 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.¹⁶⁴

CA 19-9 is a good diagnostic marker, with sensitivity of 79% to 81% and specificity of 82% to 90% in symptomatic patients, but its low positive predictive value makes it a poor biomarker for screening.¹⁶⁵

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.¹⁶⁶⁻¹⁶⁸

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.^{165,166,168-174} 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; $P < .0001$).¹⁷⁰

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.¹⁷³ 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.¹⁷⁵ 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; $P = .02$) patients.

In the advanced disease setting, data support the role of CA 19-9 as a prognostic marker.^{169,176,177} 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.¹⁷⁶ 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.¹⁷⁶⁻¹⁸¹ 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.¹⁶⁹ 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.¹⁸² 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.^{183,184} 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 jaundiced patient, 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. 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.

hENT1

A recent development in the field of advanced pancreatic cancer involves a potential predictive marker. Gemcitabine is a prodrug that must be taken into cells via a nucleoside transporter.¹⁸⁵ Human equilibrative nucleoside transporter 1 (hENT1) is a nucleoside transporter that has been studied as a predictor for response to gemcitabine. Preliminary clinical data have shown that hENT1 expression may in fact predict response to gemcitabine.¹⁸⁶⁻¹⁹¹

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.¹⁸⁷ 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 9704.¹⁸⁶ 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).^{192,193}

Unfortunately, hENT1 could also not be validated in the metastatic setting in the LEAP trial, which also used the SP120 different 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 for outcomes in patients treated with gemcitabine.¹⁹⁴ 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 handicapped by the fact that no commercial source of the antibody and no CLIA-approved testing are available.

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.¹⁹⁵ 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).¹⁹⁶ 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; $P = .01$).¹⁹⁷ An absolute survival difference of 10.3% was observed between the two groups at 5 years (20.7% vs. 10.4%).¹⁹⁷

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.¹⁹⁸ 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.¹⁹⁹ 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.²⁰⁰ 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.^{201,202} The combination of FDR gemcitabine and capecitabine has also been found to be active and well-tolerated.²⁰³

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).^{200-202,204-214} Two recent 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.^{215,216}

Combinations recommended in the advanced setting are discussed below. The panel does not consider the combination of gemcitabine plus docetaxel²¹⁷ or gemcitabine plus irinotecan^{214,217,218} to meet the criteria for inclusion in the guidelines. In addition, gemcitabine plus sorafenib is not recommended. The recent 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.²¹⁹ 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.^{208,209,211}

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.²²⁰

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.²²¹ 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).^{221,222} The addition of albumin-bound paclitaxel also improved other endpoints, including 1-year survival, 2-year survival, response rate, and PFS. 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.²²²

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. It is listed as a preferred option in this setting. 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,^{223,224} 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.²²⁵⁻²²⁹ Results of the

CALGB phase III trial, which evaluated gemcitabine and bevacizumab (an anti-vascular endothelial growth factor [VEGF] antibody) compared with gemcitabine plus placebo in patients with locally advanced or metastatic pancreatic cancer, and the Southwest Oncology Group (SWOG) phase III randomized trial, which assessed cetuximab (which targets the epidermal growth factor receptor [EGFR]) plus gemcitabine versus gemcitabine alone, did not reveal improvements in survival upon addition of the biologic agent.^{226,227} In a phase III trial comparing gemcitabine and erlotinib with or without bevacizumab in patients with metastatic pancreatic cancer, bevacizumab did not improve OS, although a significant improvement in PFS was observed with the addition of bevacizumab to the gemcitabine/erlotinib combination.²²⁹ A randomized phase III trial of another VEGF inhibitor, axitinib, in combination with gemcitabine also failed to show any improvement in OS of patients with advanced pancreatic adenocarcinoma.²²⁸ Similarly, the VEGF trap ziv-aflibercept in combination with gemcitabine did not extend OS in a phase III trial in the metastatic setting.²³⁰

In contrast, 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.²²⁵ 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 2.²²⁵ 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.^{225,231,232}

The NCCN Panel recommends gemcitabine-erlotinib combination therapy as another option for patients with locally advanced or metastatic disease and good performance status (category 1). 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.^{205,206,209}

Nevertheless, selected patients may benefit from this regimen because patients with breast and ovarian cancers who are carriers of a *BRCA* mutation²³³⁻²³⁵ and selected patients with inherited forms of pancreatic cancer⁸¹ 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.²³⁶ 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; $P < .01$).²³⁶ Furthermore, in a recent report, 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.²³⁷ 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 those with possible hereditary cancers, as a category 2A recommendation.

Gemcitabine Plus Fluoropyrimidine

A number of randomized trials have investigated the combination of gemcitabine with a fluoropyrimidine in patients with advanced pancreatic cancer. 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.²⁰⁴ 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.²⁰⁷ 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.²¹¹ 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.²³⁸ In particular, OS was better in patients receiving gemcitabine plus capecitabine than in patients receiving gemcitabine alone (HR, 0.87; *P* = .03).

Although there are concerns about dosing and toxicity of capecitabine in a U.S population, results from a recent study suggest that a biweekly

regimen of fixed-dose gemcitabine in combination with capecitabine is both effective and well tolerated in patients with advanced disease.²⁰³

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.

GTX Regimen

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.²⁰² 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 recent 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.²³⁹

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.²⁴⁰ 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).²⁴¹

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.²⁴² 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.²⁴³ Also, the Mayo Clinic and North Central Cancer Treatment Group (NCTTG) 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.²⁴⁴ Finally, if none of the above options are 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.²⁴⁵ 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.²⁴⁶ A later randomized phase II trial showed a response rate of >30% to FOLFIRINOX in patients with metastatic pancreatic cancer.²⁴⁷

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.²⁴⁸ Because of these strong results, the panel added FOLFIRINOX as a preferred, category 1 recommendation for first-line treatment of good performance status patients with metastatic pancreatic cancer in 2011. 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, however, 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.²⁴⁸ Despite the high levels of toxicity, no toxic deaths have

been reported.²⁴⁶⁻²⁴⁸ 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%, $P < .01$).²⁴⁸ 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.²⁴⁹

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.²⁵⁰ Median OS was 12.5 months in the metastatic setting and 13.7 months in patients with locally advanced disease.

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.²⁵¹

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).²⁵²

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).^{253,254} 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 the angiogenesis inhibitor sunitinib after a full course of first-line treatment may have a benefit in some patients with metastatic disease.²⁵⁵ 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.²⁵⁶ For patients with advanced disease who have received prior gemcitabine-based therapy, fluoropyrimidine-based chemotherapy regimens are acceptable second-line options.^{253,254,257} 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,^{258,259} 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 2014.²⁶⁰ 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 hazard ratio (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.²⁶¹ 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.

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.²⁶² 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.²⁶³

Chemoradiation is sometimes used for pancreatic cancer in the adjuvant setting, 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 or in resected patients if it 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.^{264,265} 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.²⁶⁴

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.²⁶⁶ 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.²⁶⁷

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.²⁶⁸ This trial, which utilized daily fractionated radiotherapy, included prospective quality assurance of all patients, including central review of preoperative CT imaging and radiation fields.²⁶⁹ 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 recently published 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.²⁷⁰

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),²⁴⁰ although the ESPAC-1 trial has been criticized for lack of attention to quality control for RT.²⁷¹⁻²⁷³ A phase II study by GERCOR randomized patients to adjuvant gemcitabine or adjuvant gemcitabine-based chemoradiation.²⁷⁴ 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 recently 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.²⁷⁵

A 2012 meta-analysis of 15 prospective, randomized trials found that adjuvant chemoradiation did not improve DFS, 2-year survival, or OS (odds ratio, 0.99; $P = .93$) compared to surgery alone, while adjuvant chemotherapy improved all 3 outcomes (odds ratio for OS, 1.98; $P < .001$).²⁷⁶ 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).²⁷⁷

However, a population-based assessment of outcomes of patients in the NCCDB 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).²⁷⁸ 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; $P < .001$).²⁷⁹

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.²⁸⁰ 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.²⁸¹ 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.²⁸² In addition, a retrospective review of resected >1200 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; $P < .001$).²⁸³ A meta-analysis of 4 randomized controlled trials 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).²⁸⁴ 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.²⁸⁵ 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 lymph node-positive and -negative patients.²⁸⁶

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.²⁸⁷ It is mainly used in selected patients who do not develop metastatic disease during initial chemotherapy.

The role of chemoradiation in locoregional pancreatic cancer was initially defined in a trial conducted in locally advanced disease by GITSG.²⁶⁵ 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.²⁸⁸ Gemcitabine has also been used as a radiation sensitizer in the locally advanced setting.²⁸⁹⁻²⁹³ 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.^{288,292,294,295} The use of capecitabine as a radiosensitizer has also been assessed in this setting and appears to be effective.²⁹⁶

A recent meta-analysis identified 15 randomized controlled trials (1128 patients) that compared chemoradiation to either chemotherapy or radiation in the locally advanced setting.²⁹⁷ 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.

Upfront Chemoradiation in Locally Advanced Disease

Results of 2 early randomized trials comparing upfront chemoradiation to chemotherapy in locally advanced disease were contradictory.^{298,299} 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.^{289,300-302} Results from small, single-arm trials of upfront chemotherapy followed by chemoradiation in locally advanced disease have been discussed.³⁰³

The more recent 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; $P = .017$).³⁰⁴ 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.³⁰⁵

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.³⁰⁶ 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. The panel points out that if patients present with poorly controlled pain or local invasion with bleeding, it may be preferable to start with upfront chemoradiation therapy.^{289,291}

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.³⁰⁷⁻³⁰⁹ 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.³⁰⁷

However, preliminary data from the international phase III LAP 07 trial showed no clear survival benefit (the primary outcome measure) with the addition of conventional chemoradiation following gemcitabine monotherapy.³¹⁰ In this study, 269 patients with disease control after induction gemcitabine-based chemotherapy were randomized to additional chemotherapy or to chemoradiation with capecitabine. Median OS was 16.5 months in the chemotherapy arm versus 15.3 months in the chemoradiation arm (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 control arm; $P < .0001$).³¹¹ 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

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.³¹²⁻³¹⁶ 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.³¹⁶ 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. Results of a recent study demonstrated that 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.^{268,317} 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% ($P = .017$),³¹⁷ suggesting that IMRT may be well tolerated and allow for higher radiation doses to the tumor.³¹⁷ There is no clear consensus on the appropriate maximum dose of radiation when IMRT technique is used.

Stereotactic body radiotherapy (SBRT) is another technique aimed at increasing dose to the gross tumor while sparing radiation to nearby healthy tissue.³¹⁸⁻³²³ 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.³¹⁸ However, another retrospective review of 71 patients reported a median OS of 10.3 months with only 3 patients (4%) experiencing grade 3 toxicity.³²¹ 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.³²⁴⁻³²⁷ Some groups, however, believe that IORT can offer benefits in very carefully selected patients with non-metastatic disease.³²⁸⁻³³⁰ Overall, there is no clear established role for IORT in patients with pancreatic cancer,³³¹ 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, debilitated 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*, 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).

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.³³² 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 ≥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.³³²⁻³⁴¹ 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.³⁴²

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.³⁴³ Early concerns about high mortality associated with various pancreatic resection procedures³⁴⁴ have now been lessened by studies demonstrating an acceptably low (<5%) mortality in experienced centers (see *Effect of Clinical Volume*, below).³⁴⁵ 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.^{196,240,241,268} 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.³⁴⁶⁻³⁴⁸ 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.³⁴⁹⁻³⁵¹

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.^{108,352} Other groups have also put forth definitions of resectability of pancreatic cancer.³⁵³⁻³⁵⁵ A more restrictive definition of borderline resectable pancreatic tumors has also been described.³⁵⁶ This definition uses degrees of contact (eg, interface between tumor and SMA measuring $<180^\circ$ 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 NCCN Pancreatic Adenocarcinoma panel has adapted the criteria put forth by other groups and lists its recommended criteria for defining resectability status in the guidelines. 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.^{355,357} 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 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 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 pancreaticoduodenectomy (ie, the Whipple procedure).^{358,359}

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 stenting or biliary bypass at that time. 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 for a non-jaundiced patient). See *Severe Tumor-Associated Abdominal Pain*, below, for more details about these procedures.

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).^{360,361} Optimal dissection and skeletonization of the SMA can best be achieved utilizing fine dissection and suture ligation. 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 results in suboptimal clearance and increases the risk of an R1 resection.^{362,363}

The panel recommends analysis of the pancreatic neck and bile duct at time of surgery by frozen section. 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.³⁶⁴⁻³⁶⁶ 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.^{366,367} Others, however, have noted poor short- and long-term outcomes with arterial resection.^{368,369} 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 recent 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.³⁶⁹ No difference in mortality was seen.

Distal Pancreatectomy

The goals of left-sided resection are similar to those of pancreatoduodenectomy, 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.^{370,371} 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.^{371,372} 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.³⁷⁰⁻³⁷² 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.^{371,372} Local recurrence, however, remains problematic even with pathologically negative margins.³⁷²

There is an increasing role for laparoscopic distal pancreatectomy. 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.³⁷³ 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.³⁷⁴ 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.³⁷⁵

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.³⁷⁶ Both autologous and synthetic grafts were used for arterial and venous reconstructions. As morbidity from pancreatoduodenectomy decreased, a subset of patients was identified 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.³⁷⁷ Furthermore, long-term outcome is not significantly worse for patients undergoing venous resection during pancreatoduodenectomy compared to patients who receive standard pancreatoduodenectomy.³⁷⁸

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.³⁷⁹⁻³⁸² 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.³⁶⁶ 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.³⁸³ 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%; $P = NS$).³⁸⁴ 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 Longmire³⁸⁵ 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 preservation³⁸⁶; however, van Berge Henegouwen et al reported longer nasogastric drainage times.³⁸⁷ In several randomized and nonrandomized studies,³⁸⁸⁻³⁹³ 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.³⁹⁴ However, a more recent multicenter, randomized, superiority trial compared the outcomes of 329 patients undergoing pancreaticoduodenectomy with either pancreaticojejunostomy or pancreaticogastrostomy.³⁹⁵ 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.³⁹⁶ Although a meta-analysis of 4 randomized controlled trials (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),³⁹⁷ the optimal approach to anastomosis remains undefined.³⁹⁸

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.^{399,400} 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.⁴⁰¹ Stents used in the 1930s and 1940s continue to be used today, but data suggest that they do not decrease leak rates.⁴⁰²

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).^{403,404} Pasireotide, in contrast, significantly decreased the rate of grade ≥ 3 fistula, leak, or abscess in a single-center, double-blind, randomized controlled trial of 300 patients (9% in pasireotide group vs. 21% in placebo group; RR, 0.44; 95% CI, 0.24–0.78; $P = .006$).⁴⁰⁵ Finally, the use of fibrin glue sealant does not appear to decrease the rate of pancreatic fistulas.⁴⁰⁶

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.^{407,408} 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.⁴⁰⁹ 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.⁴¹⁰

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.⁴¹¹ A larger randomized prospective trial was performed at Johns Hopkins Hospital from 1996 through 2001 to evaluate the role of extended lymph node dissections.⁴¹² 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.⁴¹²⁻⁴¹⁴ Recently, a randomized multicenter trial in Japan came to similar conclusions.⁴¹⁵ Furthermore, multiple systematic literature reviews and meta-analyses of randomized controlled trials comparing pancreatoduodenectomy with standard versus extended lymphadenectomy support the conclusion that the extended procedure does not have any impact on survival.⁴¹⁶⁻⁴¹⁸ In addition, patients undergoing extended lymphadenectomy have increased rates of postoperative diarrhea compared to patients undergoing the standard resection.⁴¹⁹

The information to date thus does not show any survival advantage to performing a regional lymphadenectomy in addition to the standard pancreatoduodenectomy.⁴²⁰ 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.^{421,422}

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.⁴²³⁻⁴²⁵ 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.⁴²⁶⁻⁴³² 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.⁴³³ 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.⁴³⁴

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.⁴³⁵ 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.⁴³⁶⁻⁴³⁹

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 *Palliation and Supportive Care*, below). While any stent can become occluded, several groups have reported better patency with metal stents.⁴³⁷⁻⁴³⁹ 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,⁴⁴⁰ but the reported differences between covered and uncovered stents are not dramatic.^{440,441} Furthermore, migration is more of an issue with covered stents.⁴⁴¹ This issue has led to the introduction of partially covered stents,⁴⁴² though

these stents may still migrate in a substantial number of patients.^{443,444} Most metal stents used today are self-expanding. Their small initial diameters make them easy to place, and their placement rarely requires dilation.⁴⁴² Several panel members reported that their institutions use plastic stents in patients with short life expectancies (<3 months).⁴⁴² 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%).⁴⁴⁵ 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.⁴⁴⁶⁻⁴⁵⁰ 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.⁴⁵¹⁻⁴⁵³

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).⁴⁵⁴ 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 >16 procedures per year were classified as “high” and “very-high” volume centers.⁴⁵⁵ 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.⁴⁵⁶ In addition, a recent 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 ($P = .008$).⁴⁵⁷ 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.⁴⁵⁸

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.⁴⁵⁹ 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 2013.⁴⁶⁰ 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.^{461,462}

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.⁴⁶⁰ Recent retrospective database analyses have found that patients with N0 disease have a better prognosis with an increasing number of examined lymph nodes.⁴⁶³⁻⁴⁶⁵ 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.^{463,465,466} 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.⁴⁶³⁻⁴⁷⁰ For instance, in one analysis, patients with <15% of examined positive nodes had a 5-year

survival rate of 21.7%, while those with >15% positive nodes had a 5.2% 5-year survival rate ($P = .0017$).⁴⁶⁸

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 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.^{459,471-473} 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; $P < .001$).⁴⁷⁴ In fact, the close-margin R0 patients had a median survival time similar to that of the R1 population (16 months vs. 14 months; $P = .6$). Consistent with these

results, another recent 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).^{475,476} 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 ($P = .10$).⁴⁷⁷ Together, these results suggest that an appropriate definition of a negative margin may be >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 levels¹⁹⁶), 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.

Based on the data discussed above, no definite standard has been established in the adjuvant treatment of pancreatic cancer at this time. Gemcitabine- or fluoropyrimidine-based chemoradiation with additional gemcitabine, continuous infusion 5-FU, or 5-FU/leucovorin chemotherapy and 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.

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. While no studies have demonstrated superiority of giving chemoradiation before versus after chemotherapy in the adjuvant setting, when patients have a margin-positive resection, upfront chemoradiation followed by systemic chemotherapy is an appropriate option.

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.⁴⁷⁸ 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.

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.^{196,240,241,268} 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.^{337,340} Neoadjuvant therapy is also sometimes used in resectable patients, especially in those with high-risk features. The putative benefits of neoadjuvant therapy include increasing the likelihood that a higher proportion of resectable patients 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.^{339,341,355,479} Moreover, surgery following neoadjuvant treatment appears to be safe.^{480,481}

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, as discussed in *Preoperative Biliary Drainage*, above) is recommended prior to initiation of neoadjuvant therapy in patients with jaundice.⁴³⁷⁻⁴³⁹

There is insufficient evidence to recommend specific neoadjuvant regimens, and practices vary with regards 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.

Abdominal (pancreas protocol), pelvic, and chest imaging 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.^{482,483} 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 have the options of upfront resection (category 2B) with adjuvant therapy or 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, the panel down-

graded its recommendation for upfront resection in borderline cases to category 2B in the 2014 version of these guidelines.

Several trials have shown that preoperative treatment of borderline resectable pancreatic adenocarcinoma can be effective and well-tolerated.⁴⁸⁴⁻⁴⁸⁹ A phase I/II trial of neoadjuvant therapy in borderline resectable disease allowed 4 of 26 patients (15%) to be resected.⁴⁸⁸ 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.⁴⁸⁷ 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%.⁴⁸⁶ 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 borderline resectable patients who completed neoadjuvant therapy had R0 resections.^{490,491} A systematic review and meta-analysis of 19 cohort studies found that unresectable patients (including both borderline and unresectable patients) undergoing neoadjuvant chemoradiation therapy had similar 1-year survival outcomes as patients who were initially deemed resectable.⁴⁹² 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.³⁵⁶ Initial results in patient series suggest that neoadjuvant regimens including FOLFIRINOX are a promising approach in patients with borderline resectable disease.^{493,494} 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.^{339,340,495-503} 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.⁴⁹⁶ 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.⁴⁹⁶ 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.⁴⁹⁶ The MD Anderson group has continued to champion this approach both for its ability to select patients for resection and for cost-effectiveness.⁵⁰⁴ Other potential advantages of the neoadjuvant approach in resectable patients 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.^{481,505,506}

Although most studies investigating the neoadjuvant experience in patients with resectable pancreatic cancer are retrospective, several small phase II studies have been published.^{481,505,507,508} 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.⁵⁰¹

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.⁴⁹⁸ 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.⁴³⁸ 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.⁴⁷⁹ 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,⁵⁰⁹ 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.⁵¹⁰ 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).⁵¹¹ 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 most resectable patients, except in a clinical trial. For selected patients who appear technically resectable but have poor prognostic features (ie, borderline resectable disease; markedly elevated CA 19-9; large primary tumors; large regional lymph nodes; highly symptomatic), however, consideration can be given to neoadjuvant therapy after biopsy confirmation, although a clinical trial is still preferred.

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.

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 Resected Patients

Although data on the role of surveillance in patients with resected pancreatic adenocarcinoma are very limited,⁵¹²⁻⁵¹⁴ 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 annually. 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, a recent analysis of the SEER-Medicare database showed no significant survival benefit for patients who received regular surveillance CT scans.⁵¹⁵

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.⁵¹⁶ 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 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.^{517,518} Preliminary data also suggest that pulmonary metastasectomy may be advantageous in this population.⁵¹⁹ 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.⁵²⁰ For patients diagnosed with unresectable disease and biliary obstruction upon initial evaluation, the best palliation is provided by an endoscopic biliary stent, especially when anticipated survival is limited. In most cases, a permanent self-expanding metal stent (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 a randomized,

controlled trial of 100 patients at a single center randomly assigned to receive either a plastic stent or a covered self-expanding metal stent inserted endoscopically indicated that median patency times were 1.8 and 3.6 months ($P = .002$), respectively.⁵²¹ A meta-analysis comparing metal and plastic biliary stents placed endoscopically in patients with pancreatic adenocarcinoma characterized by biliary obstruction showed similar results.⁵²² 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.⁵²³

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.⁵²⁴ Durable palliation of biliary obstruction can often be achieved with an expandable metallic biliary endoprosthesis (eg, Wallstent, Boston Scientific) in this situation.⁵²⁴

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^{525,526}) and with or without celiac plexus neurolysis⁵²⁷⁻⁵²⁹ (category 2B in non-jaundiced patients). Please 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.⁵²⁰

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^{525,526}) 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 jaundiced patient, 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.⁵²⁰ 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.⁵²⁴ 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.⁵³⁰⁻⁵³² 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 randomized controlled trials have investigated the role of prophylactic gastrojejunostomy for unresectable periampullary cancer, the majority arising from the head of the pancreas.^{525,526} 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.⁵³³ 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.⁵²⁹ General principles for cancer-related pain management can be found in the NCCN Guidelines for Adult Cancer Pain (available at www.NCCN.org). Because advanced pancreatic cancer often infiltrates the retroperitoneal nerves of the

upper abdomen, celiac plexus neurolysis should be considered for pain. In several randomized controlled trials, celiac plexus neurolysis significantly improved pain relief in patients with advanced pancreatic cancer.^{527,529,534} In a recent 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.⁵²⁸ 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 randomized controlled trials concluded that celiac plexus neurolysis improved pain scores at 4 weeks but not at 8 weeks in patients with pancreatic cancer.⁵³⁵

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 patients with pain found to be unresectable at surgery, celiac plexus neurolysis can be performed intraoperatively; the procedure is sometimes also performed prophylactically at the time of surgery in patients without pain who are found to be unresectable (category 2B).

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.^{536,537} This deficiency in pancreatic enzymes results in inadequate absorption of fat, carbohydrates, and proteins, leading to steatorrhea, abdominal cramps, weight loss, and malnutrition.⁵³⁸ 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,^{539,540} 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.⁵³⁸ For patients not responding 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.^{538,539} 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.^{541,542} 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.⁵⁴³ In the CONKO 004 trial, VTE- and chemotherapy-naïve patients with advanced pancreatic cancer were randomized to receive palliative chemotherapy with or without the LMWH, enoxaparin.⁵⁴⁴ 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. Please see the NCCN Guidelines for Venous Thromboembolic Disease, available at www.NCCN.org, for more information.

Depression, Pain, and Malnutrition

For many patients, a diagnosis of pancreatic cancer may result in significant psychosocial distress, including anxiety, depression, and sleep disturbances.⁵⁴⁵ In fact, the suicide rate in male patients with pancreatic cancer is reportedly 11 times that of the general population.⁵⁴⁶ 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.⁵⁴⁷

- 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.⁵⁴⁸ 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.⁵¹⁶ 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.⁵⁴⁹ 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.⁵⁵⁰ 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.⁵⁵¹

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.³⁵⁶ Endpoints should also be standardized and could include resection rates, R0 resection rates, local recurrence rates, pathologic response rates, DFS, and OS.⁵⁵²

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. Borderline resectable patients and select resectable patients can undergo neoadjuvant

therapy in the hopes of improving the chances for an R0 resection or can immediately undergo surgery (category 2B). 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. Good performance status patients presenting with metastatic disease can undergo chemotherapy and can undergo 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 ⁵⁹	132-fold ⁵⁸
Familial Pancreatitis	<i>PRSS1</i> , <i>SPINK1</i> , <i>CFTR</i>	40%–53% by age 70–75 years ⁶³⁻⁶⁵	26-fold to 87-fold ^{29,63-65}
Melanoma-Pancreatic Cancer Syndrome	<i>CDKN2A</i>	17% by age 75 years ⁶⁸	20-fold to 47-fold ^{67,68}
Lynch Syndrome	<i>MLH1</i> , <i>MSH2</i> (<i>MSH6</i>)	4% by age 70 years ⁷⁷	9-fold to 11-fold ^{77,78}
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 ^{79,84}	2.4-fold to 6-fold ^{79,83,84}
Familial Pancreatic Cancer	Unknown in most families (family X is an exception)*	<p>≥3 first-degree relatives with pancreatic cancer: 7%–16% by age 70⁵¹</p> <p>2 first-degree relatives with pancreatic cancer: 3% by age 70⁵¹</p>	<p>≥3 first-degree relatives with pancreatic cancer: 32-fold⁹⁰</p> <p>2 first-degree relatives with pancreatic cancer: 6.4-fold⁹⁰</p> <p>1 first-degree relative with pancreatic cancer: 4.6-fold⁹⁰</p>

*One family (family X) with a mutation in the *palladin* (*PALLD*) gene has been identified.⁵⁵³

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

Regimen	Resectable (adjuvant)	Borderline Resectable (neoadjuvant)	Locally Advanced	Metastatic (good performance status)
Gemcitabine	√ (category 1)		√ (category 1 for poor performance status)	√ (category 1 for good and poor performance status)
Gemcitabine/Albumin-Bound Paclitaxel		√	√	√ (category 1; preferred)
Gemcitabine/Erlotinib			√	√ (category 1; survival benefit is small)
Gemcitabine/Cisplatin			√ (especially if possible hereditary cancer)	√ (especially if possible hereditary cancer)
Gemcitabine/Capecitabine			√	√
Fixed-dose-rate gemcitabine			√	√ (category 2B)
GTX [Fixed-dose-rate gemcitabine/docetaxel/capecitabine]			√ (category 2B)	√ (category 2B)
5-FU/Leucovorin	√ (category 1)			
FOLFIRINOX		√	√	√ (category 1; preferred)
Capecitabine	√ (category 2B)		√ (category 2B)	√ (category 2B)
Continuous Infusion 5-FU	√		√ (category 2B)	√ (category 2B)
Fluoropyrimidine/Oxaliplatin (eg, FOLFOX, CapeOx)			√ (category 2B)	√ (category 2B)
Radiation	√ (fluoropyrimidine- or gemcitabine-based)	√ (subsequent chemoradiation is sometimes included)	√ (in select patients without systemic metastases; fluoropyrimidine- or gemcitabine-based)	√ (palliative only)

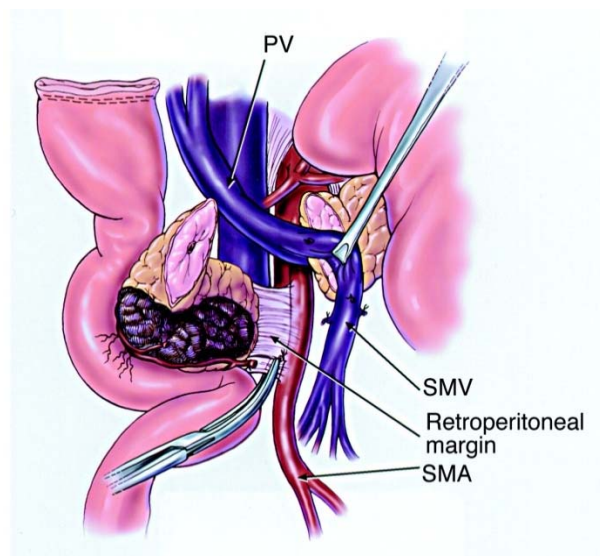


Figure 1. Complete mobilization of the superior mesenteric (SMV) and portal veins, and separation of the specimen from the right lateral border of the superior mesenteric artery (SMA).⁵⁵⁴

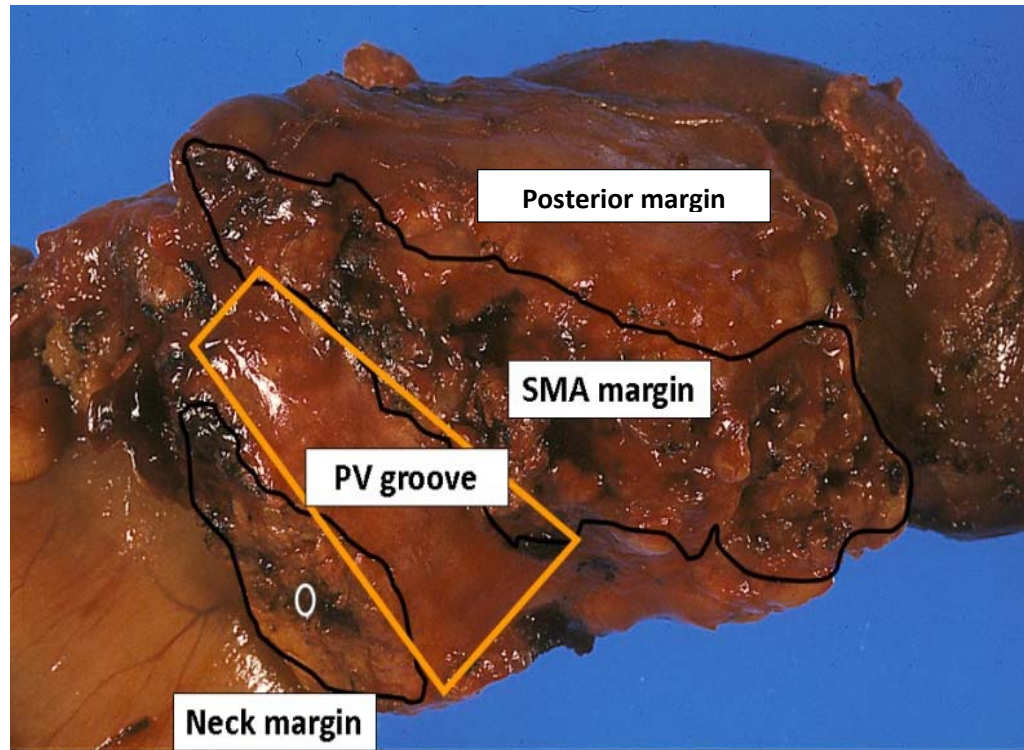
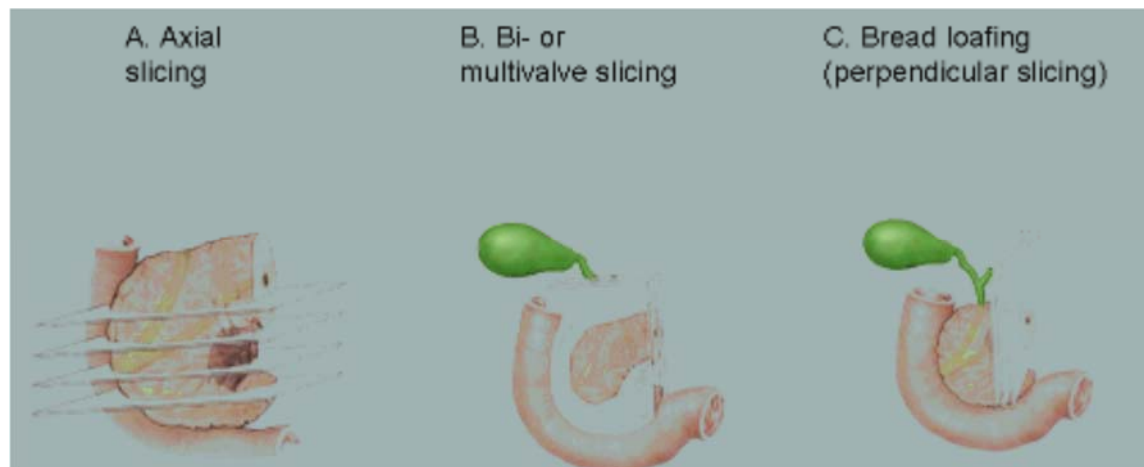


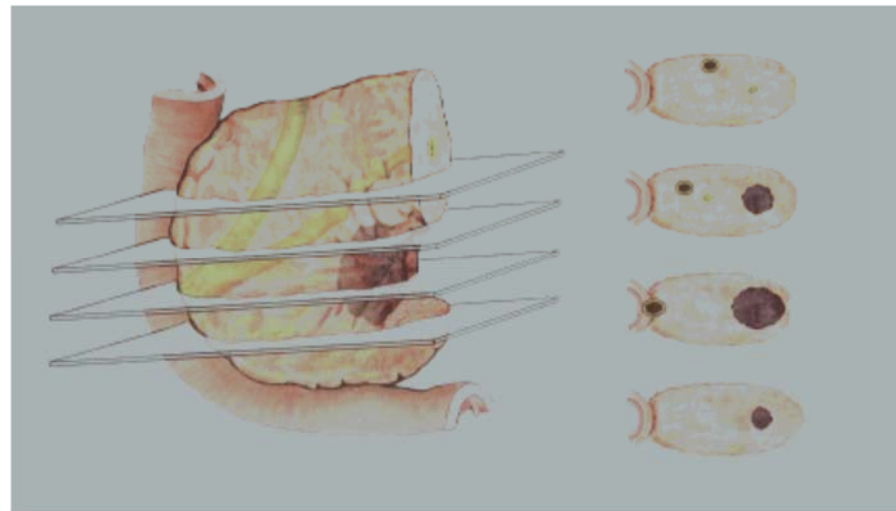
Image courtesy of Dr. N. Volkan Adsay

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.⁴⁵⁹



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.⁴⁵⁹

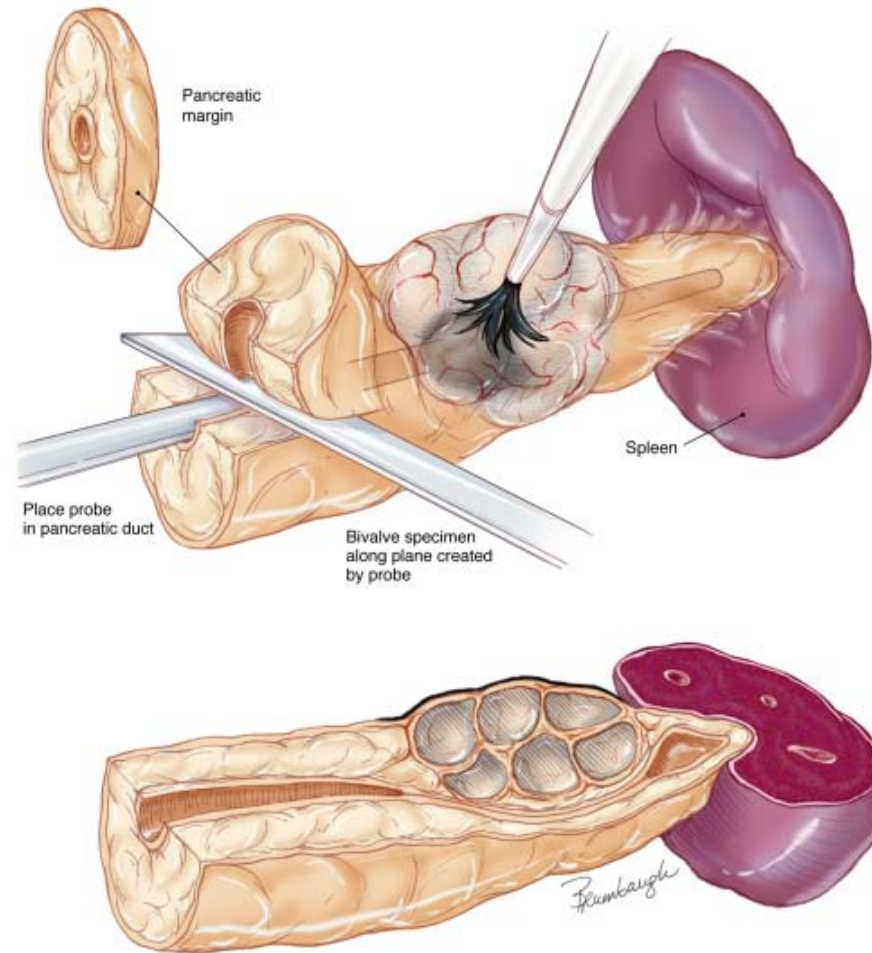


Figure 16-4, from Hruban, Ralph et al. Tumors of the Pancreas: Afip Atlas of Tumor Pathology, American Registry of Pathology, Washington DC 2007

Figure 5. Slicing of the distal pancreatectomy specimen.⁴⁷³

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