American College of Radiology
ACR Appropriateness Criteria®
Staging of Pancreatic Ductal Adenocarcinoma

<u>**Variant 1:**</u>　　　　　**Pancreatic ductal adenocarcinoma. Initial staging pretreatment.**

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen without and with IV contrast	Usually Appropriate	O
MRI abdomen without IV contrast	May Be Appropriate	O
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
US abdomen endoscopic	May Be Appropriate	O
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
US abdomen transabdominal	Usually Not Appropriate	O

<u>**Variant 2:**</u>　　　　　**Pancreatic ductal adenocarcinoma. Follow-up post-neoadjuvant therapy. Evaluate resectability for borderline resectable tumor.**

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen without and with IV contrast	Usually Appropriate	O
MRI abdomen without IV contrast	May Be Appropriate	O
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	☢☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
US abdomen endoscopic	Usually Not Appropriate	O
US abdomen transabdominal	Usually Not Appropriate	O

<h1 style="text-align:center">STAGING OF PANCREATIC DUCTAL ADENOCARCINOMA</h1>

Expert Panel on Gastrointestinal Imaging: Aliya Qayyum, MD[a]; Eric P. Tamm, MD[b]; Ihab R. Kamel, MD, PhD[c]; Peter J. Allen, MD[d]; Hina Arif-Tiwari, MD[e]; Victoria Chernyak, MD, MS[f]; Tamas A. Gonda, MD[g]; Joseph R. Grajo, MD[h]; Nicole M. Hindman, MD[i]; Jeanne M. Horowitz, MD[j]; Harmeet Kaur, MD[k]; Michelle M. McNamara, MD[l]; Richard B. Noto, MD[m]; Pavan K. Srivastava, MD[n]; Tasneem Lalani, MD.[o]

Summary of Literature Review

Introduction/Background

Prevalence, Etiology, Treatment, and Prognosis

According to the American Cancer Society, the number of new pancreatic cancer cases estimated in the United States in 2017 is 53,670 [1]. The estimated number of deaths is 43,090 in 2017, with pancreatic adenocarcinoma remaining the fourth leading cause of cancer-related death in the United States. Difficulty in early detection and lack of effective screening methods invariably results in an advanced stage at presentation and poor prognosis.

Associated risk factors include tobacco use (20% of patients), family history of pancreatic cancer (two or more first-degree relatives with pancreatic cancer reported in 10% of patients), chronic pancreatitis, diabetes, obesity, hereditary pancreatitis [2-4] and genetic alterations such as *BRCA1, BRCA2, PALB2, p16* gene mutations, Lynch syndrome, and Peutz-Jeghers syndrome [5,6]. Screening is not currently recommended for the general population (US Preventive Services Task Force gives a D recommendation) [7]. However, some have suggested that screening patients at high risk of developing pancreatic cancer is feasible, while acknowledging that data for cost-effectiveness and benefit are still required [8]. To date, the most suitable imaging technology for such screening is unclear [5]. No specific tumor markers for pancreatic cancer exist, and although most patients will demonstrate elevation in serum cancer antigen 19-9, this has low specificity and is more often used to indicate disease progression.

Pancreatic cancer develops insidiously in the exocrine cells, and as such, early disease is often asymptomatic or presents with vague symptoms such as loss of appetite, fatigue, and general malaise. Consequently, 80% to 85% of patients present with advanced disease without the option of surgical resection [9].

Overall survival for pancreatic cancer is 28% after 1 year and 7% after 5 years [1]. Localized pancreatic cancer, reportedly diagnosed in 9% of patients, is associated with a 26% 5-year survival. Distant stage disease at diagnosis is associated with only a 15% 1-year and 2% 5-year survival [1]. Given the poor prognosis, accurate staging is essential and pivotal to patient management decisions that are decided through a multidisciplinary approach [5]. Imaging plays a critical role in pancreatic cancer staging and therapeutic decision process. The imaging armamentarium used to evaluate pancreatic cancer includes multidetector computed tomography (MDCT), magnetic resonance imaging (MRI), endoscopic ultrasound (EUS), and fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET)/CT.

According to the AJCC (American Joint Committee on Cancer) handbook [7], pancreatic cancer is staged according to TNM (tumor, node, metastases) classification. TX and T0 refer to tumors that cannot be evaluated or when there is no evidence for a primary tumor, respectively. T1 tumors are entirely intrapancreatic and ≤2 cm. T2 tumors are entirely intrapancreatic and >2 cm. T3 tumors extend beyond the pancreas without involvement of either the celiac or superior mesenteric arteries. T4 tumors involve the superior mesenteric or celiac arteries. NX refers to the inability to evaluate the status of lymph nodes, whereas N0 indicates no nodal involvement and N1 designation refers to tumor involvement of regional nodes. M0 means no metastatic involvement, whereas M1 designation means there are distant metastases.

[a]Principal Author, University of Texas MD Anderson Cancer Center, Houston, Texas. [b]Research author, University of Texas MD Anderson Cancer Center, Houston, Texas. [c]Panel Chair, Johns Hopkins University School of Medicine, Baltimore, Maryland. [d]Memorial Sloan Kettering Cancer Center, New York, New York; American College of Surgeons. [e]University of Arizona, Banner University Medical Center, Tucson, Arizona. [f]Montefiore Medical Center, Bronx, New York. [g]Columbia University, New York, New York; American Gastroenterological Association. [h]University of Florida College of Medicine, Gainesville, Florida. [i]New York University Medical Center, New York, New York. [j]Northwestern University, Chicago, Illinois. [k]University of Texas MD Anderson Cancer Center, Houston, Texas. [l]University of Alabama Medical Center, Birmingham, Alabama. [m]The Warren Alpert School of Medicine at Brown University, Providence, Rhode Island. [n]University of Illinois College of Medicine, Chicago, Illinois; American College of Physicians. [o]Specialty Chair, University of Washington, Seattle, Washington.

Key determinants of tumor stage can be summarized as follows: Stage IV disease is the presence of any distant metastases, stage III disease is any T4 disease, stage IIA disease is T3 disease with no distant metastases or nodal involvement, stage IIB disease is T1 through T3 disease with nodal involvement, stage IA is T1 disease without nodal involvement, and stage IB is T2 disease without nodal involvement.

Treatment options include surgery, radiation therapy, and chemotherapy. Radical surgical resection offers potentially curative therapy, though it is seldom achieved. Furthermore, the general procedure-related morbidity rate is high at 20% and mortality rate is 1% to 4% [10,11].

Less than 20% of patients are candidates for surgery. For those undergoing surgery, the cancer is often too extensive for removal. Adjuvant chemotherapy with gemcitabine or chemoradiation after surgery has been reported by some to improve survival, but this is controversial due to conflicting published results [12-15]. Use of combination systemic therapy with gemcitabine and the targeted anticancer drug erlotinib, has been suggested to slightly increase survival in patients with advanced cancer [1].

Cure rates are highest for tumors that are truly localized to the pancreas (without extension beyond the pancreatic capsule or lymph node metastases). Surgical resection of small, localized tumors, (measuring <2 cm in maximum diameter), are associated with a survival rate of 18% to 24% [16].

Decisive factors determining tumor resectability include presence of distant metastases, and vascular involvement particularly the celiac axis, superior mesenteric artery (SMA), superior mesenteric vein (SMV), and portal vein (PV). Motivation in efforts to increase surgical candidates is consequent to complete tumor resection being the sole option for cure. Close collaborative efforts between surgeons, oncologists, radiation oncologists, and diagnostic imaging has resulted in the development of resectable and borderline resectable disease criteria over the last decade. Increasingly sophisticated surgical techniques, including complex vascular reconstruction and use of neoadjuvant and adjuvant therapies have increased demand of more detailed and specific radiological interpretation of disease extent. Surgical definition of borderline resectable pancreatic cancer is based on five important observations: 1) long-term survival necessitates complete resection of the primary tumor and regional lymph nodes; 2) negative resection margins are less likely with increasing tumor involvement of the SMV-PV and SMA; 3) SMV-PV and hepatic artery resection (not SMA) at pancreatectomy has been associated with acceptable outcomes; 4) administration of conventional cytotoxic agents rarely results in down-staging locally advanced pancreatic cancer; and 5) tumor response to neoadjuvant chemotherapy and chemoradiation may be indicative of favorable tumor physiology and biology, and thus used to select patients who may benefit from aggressive surgery [17-25].

The most commonly used criterion for defining borderline resectable pancreatic cancer is radiologic evidence of <180° tumor interface to SMA [21]. However, there is a lack of consensus on criteria for SMV involvement. Principally, differences in distinguishing borderline resectable and resectable cancer are based on radiologic determination of SMV-PV involvement. The American Hepatopancreatobiliary Association (AHPBA), Society for Surgery of the Alimentary Tract (SSAT), and the Society of Surgical Oncology (SSO) consider any degree of SMV-PV abutment criterion for borderline resectable cancer [22]. MD Anderson categorizes presence of venous occlusion as a feature of borderline resectable cancer, but tumor abutment (≤180°) or encasement (>180°) of SMV-PV as resectable cancer. Patients with both borderline resectable or resectable pancreatic cancer are treated with neoadjuvant chemoradiation at this institution [18]. Current surgical techniques are directed at removing sites of potential perineural tumor spread by performing vascular resection if there is possibility of the two venous ends being joined by a single lumen. Types of vascular reconstruction include venous grafts (saphenous vein), interposition grafts (internal jugular vein), primary anastomosis if there is sufficient native vein available, or splenic ligation [26].

Overview of Imaging Modalities

Radiologic evaluation of patients with pancreatic cancer for staging should assess tumor size, extension of tumor beyond the pancreas including adjacent significant vasculature (namely the SMA, celiac artery, common hepatic artery, and splenic artery, hepatic arterial variants, and the main PV, splenic vein, SMV, and whether the tumor is extending to divisions of these veins, which would preclude placement of a graft), presence of regional adenopathy (especially nodes that may be beyond the surgical field and may be suspicious, based on size or morphology), and whether there is metastatic involvement of the liver, peritoneum, and lungs.

US

Transabdominal ultrasound (US) is typically used in the initial workup of abdominal pain or suspected obstructive jaundice and has been addressed separately in the ACR Appropriateness Criteria® "Jaundice" [27]. Difficulties in visualizing the pancreas in detail because of either body habitus or commonly interposed bowel gas limit its usefulness in staging.

CT

At many institutions, contrast-enhanced MDCT is the preferred imaging technique for the staging of pancreatic cancer. It is quick, robust, and especially has superb spatial resolution. It is particularly useful for the assessment of tumor involvement of vascular structures. Imaging should be obtained as a multiphasic acquisition, with a late arterial phase timed to optimize peak enhancement of the pancreas (typically at 45-50 seconds after the start of contrast injection, depending on injection rate) to maximize visualization of the primary tumor, and a portal venous phase for optimum enhancement of venous structures and to maximize detectability of typically hypodense liver metastases (typically 70 seconds after the start of contrast injection) [28]. Many practices employ use of bolus tracking to optimize timing of the arterial and portal venous phase of enhancement. A recent study comparing 64-detector row MDCT and 3T MRI showed overall comparable sensitivities and specificities between the two modalities regarding resectability (CT sensitivity 87%, specificity 63% to 75%; MRI sensitivity 93%, specificity 50% to 75%) [11]. A recent critical review of CT and MRI that was based on reports published between 1997 and 2009 also showed that CT and MRI performed comparably with both modalities showing improvement on more recent studies [29]. Notably, unenhanced CT has poor soft tissue contrast in comparison to MRI and therefore has marginal usefulness during staging. It should also be noted anecdotally, for the reasons given above, that in those institutions with MRI and CT capabilities, CT is typically the more used modality in the setting of staging pancreatic cancer.

MRI

Many MRI advances have been made in the past several years with regard to robustness of image quality, speed of image acquisition, and resolution in imaging. As noted above, MRI has been reported in a recent study to have a sensitivity of 93% and specificity of 50% to 75% for determination of resectability [11], and studies comparing state-of-the-art CT with state-of-the-art MRI report a similar overall performance [29]. MRI has inherently better soft tissue contrast than unenhanced CT enabling superior visualization of tumor without intravenous (IV) contrast administration. Although we could not identify studies specifically addressing noncontrast MRI staging sensitivity and specificity, MRI is preferable because techniques such as flow sensitive sequences and diffusion-weighted imaging provide valuable information when IV contrast is contraindicated.

EUS

EUS is a relatively invasive modality whose primary role in the evaluation of pancreatic cancer has been in the detection and guidance of biopsy for confirmation of tumor as discussed in the ACR Appropriateness Criteria® "Jaundice" [27]. It has evolved into a useful modality to complement CT and MRI for the workup of questionable lesions given a sensitivity of near 100% and specificity of reportedly ≥95% for tumors <2 cm in the absence of administration of IV contrast [29,30]. The ability to perform fine-needle aspiration (FNA) also proves useful in the assessment of questionable metastatic lymph nodes, but EUS is unable to assess for potential liver metastases or peritoneal disease. Furthermore, the results have been mixed regarding its sensitivity and specificity for vascular involvement when compared to CT or MRI [29,30]. In this regard, EUS may be helpful as a problem solver when there are contraindications to both MRI and contrast-enhanced CT. However, as will be discussed subsequently in variant 1 in greater detail, criteria for describing vascular invasion on EUS have not been standardized rendering comparative assessments limited.

FDG-PET/CT

There is considerable variation in how FDG-PET/CT is performed between institutions, with regard to the presence or absence of IV contrast, the presence or absence of oral contrast, as well as other parameters including slice thickness, and field-of-view. When performed without IV contrast, FDG-PET/CT has the same limitations as unenhanced CT with regard to local staging of the tumor. When performed with IV contrast, images are typically obtained at a single phase of contrast enhancement. Studies that have recently examined the role of FDG-PET/CT in the staging of pancreatic cancer have focused on its supplementary ability to detect additional distant metastases beyond those detected by conventional cross-sectional imaging of the abdomen and pelvis or chest, abdomen, and pelvis given the advantage that FDG-PET/CT is a whole-body examination [31].

Discussion of Procedures by Variant

Variant 1: Pancreatic ductal adenocarcinoma. Initial staging pretreatment.

CT

With regard to assessing vascular involvement, one of the limitations of the literature are varying definitions for what constitutes vascular invasion or "vascular involvement," and even more, the criteria for resectability as a definition of "resectable" disease varies between institutions. As an example, a recent study of 111 patients defined its criterion for arterial invasion as any contiguity between tumor and vessel, whereas venous invasion was described as only being present if there was a 50% or greater contiguity of tumor with a given vein [32]. A meta-analysis of examinations performed between 1999 and 2010 that compared CT and MRI showed that CT had a sensitivity of approximately 71% and specificity of approximately 92% for identification of vascular invasion across arteries and veins, which is comparable to MRI [33].

Nodal staging is a limitation for any of the imaging modalities because of its relative insensitivity to micrometastases detection. Another challenge is the varying imaging criteria for identifying potential nodal involvement between studies. A recent study that used, as criterion for nodal involvement, a nodal short axis diameter of >5 mm or morphologic features of necrosis showed an accuracy of 55% to 60% for the detection of nodal metastatic disease, which is similar to findings seen on older studies regardless of criteria (44%-68%) [29,32,34,35].

Little information is available regarding sensitivity for detecting liver metastases originating from pancreatic cancer for the current generation of MDCT scanners (64-detector row or better). Two studies that have compared 64-detector row MDCT with 3T MRI showed for CT a sensitivity of 70% to 76% in the detection of liver metastases compared to 90% to 100% for MRI with either gadobenate dimeglumine or gadoxetic acid [33,36]. Ikuta et al [37] studied 192 patients to compare 4-detector row multiphasic MDCT with CT arterial portography (CTAP) and computed tomography-assisted hepatic arteriography (CTHA) with intraoperative US as the gold standard in the assessment of those patients identified as not having metastatic disease. Of note, CTAP with CTHA is an invasive technique requiring a separate interventional procedure for placement of an arterial catheter to optimize contrast evaluation by CT, and as such is not practiced routinely. Furthermore, MDCT was performed with only four detectors, which is far less than many contemporary scanners. In that study, MDCT had a sensitivity of 48.4% and specificity of 98% for liver metastases compared to CTAP + CTHA, which had a sensitivity of 94.2% and specificity of 82.7%. Although the results of CTAP + CTHA were impressive, the data regarding current state-of-the-art MDCT are not representative of modern practice.

Peritoneal metastases from pancreatic cancer are typically difficult to identify by any of the modalities because of their typically small size or miliary appearance. In our literature search, no studies that tried to assess overall sensitivity for peritoneal metastases by CT were available, likely because patients were already found to have unresectable disease secondary to other causes such as liver metastases or extensive vascular involvement. Studies that were retrieved in our examination focused on the question of the additional usefulness of preoperative laparoscopic assessment following CT. Results have been controversial, but indirectly these provide information regarding whether CT is sufficient for detection of peritoneal disease for disease management. A meta-analysis of 1,015 patients across 15 studies concluded that, on average, out of 100 patients identified as having resectable disease based on CT, use of follow-up laparoscopy would have avoided 23 unnecessary laparotomies [38]. Another recent meta-analysis that analyzed 12 studies between 1999 and 2010 showed a pooled sensitivity of laparoscopic assessment of 75% for peritoneal implants [39]. In our anecdotal experience, institutions will variably use laparoscopy, sometimes in the setting of suspicion for peritoneal disease, but for some others more globally, with or without laparoscopic peritoneal washing, with the plan to proceed directly to laparotomy at the same setting for planned pancreatic resection in the absence of detection of peritoneal disease.

MRI

The limitations noted above for studies regarding CT and the accuracy of assessing vascular involvement by tumor apply to MRI as well (with differences in criteria for defining a vessel as involved by tumor, differences in definitions of resectability, and varying generations of equipment, etc.). Fewer studies are available on the topic of MRI and staging of pancreatic cancer than there are for CT. A study comparing 64-detector row MDCT versus 3T MRI showed for MRI a sensitivity for vascular infiltration of 50% to 80% and a specificity of 96% to 98% [11]. These findings are similar to those found on a meta-analysis of eight studies published between 1997 and 2004 that showed a pooled sensitivity of 67% and pooled specificity of 94% that was not significantly different

from CT [33]. Therefore, MRI and CT can be considered likely comparable with regard to assessment of vascular involvement by tumor.

As noted above, assessment for nodal staging on cross-sectional imaging is limited because of its current inability to identify micrometastases. A critical review article on staging reportedly noted an accuracy ranging from 61% to 77% in radiology studies from 2004 to 2009 for the detection of nodal involvement by tumor [29].

In contrast, MRI has been shown to be likely superior for the detection of liver metastases. Two studies that compared 64-detector row MDCT with 3T MRI showed that CT had a sensitivity of 70% to 76% for the detection of liver metastases compared to 90% to 100% for MRI with either gadobenate dimeglumine or gadoxetic acid [33,36].

The literature search identified only very limited information with regard to MRI and pancreatic cancer peritoneal metastases. A study evaluating the usefulness of staging laparoscopy following staging MRI noted that the yield of staging laparoscopy was marginal and cost effectiveness was reportedly poor for use of this approach [40].

EUS
A recent meta-analysis of 29 studies that incorporated EUS showed EUS to have a pooled sensitivity of 85% and specificity of 91% for vascular invasion [41]. Notably, the same study noted that the criteria for identifying arterial invasion have not been standardized, which is a constraining factor when attempting to compare between modalities and likely accounts for the wide range of sensitivity for vascular invasion of EUS in this meta-analysis (62% to 100%). The authors noted in their review that there are little comparative data between arterial and venous assessments, and that overall it appeared that CT and EUS performed comparably for assessing venous involvement and that CT may be superior for the assessment of invasion of arterial structures [41].

With regard to nodal disease, EUS has the advantage in that it can be combined with FNA to greatly improve its specificity. A recent meta-analysis of 8 studies showed a pooled sensitivity of 58% and specificity of 85% for detecting nodal metastases with EUS alone [41]. Although the meta-analysis did not include an assessment of multiple studies with EUS that included FNA, the authors did note that EUS would likely improve nodal staging, and cited a study that reported a sensitivity of 82% and specificity of 100% to confirm malignant adenopathy [42].

Because of its narrow field-of-view, and the limited region of anatomic coverage, EUS does not have a role for assessment of peritoneal disease. EUS allows for a limited examination of the left liver lobe and possible FNA of these lesions. No studies have directly compared the accuracy of EUS and cross-sectional imaging for left-sided liver metastasis. Imaging of the right liver is difficult and unreliable by EUS.

US
Difficulties in visualizing the pancreas in detail because of either body habitus or commonly interposed bowel gas limit the usefulness of transabdominal US for staging.

FDG-PET/CT
As noted earlier, there is considerable variability in how the CT portion of the examination is obtained for FDG-PET/CT with regard to whether IV or oral contrast is administered. When performed without IV contrast, it does not have a role in the assessment for potential vascular involvement. When performed with IV contrast enhancement, it is typically acquired as a single phase of contrast enhancement at variable slice thickness and variable reconstructed display field-of-view between institutions. These parameters would affect the usefulness and effectiveness of local staging. FDG-PET/CT, when used in the setting of preoperative staging, is therefore typically used as a whole-body examination for follow-up to contrast-enhanced CT or MRI, which themselves would already provide information regarding liver metastases, potential peritoneal implants, and possible adenopathy. This is likely why most of the studies retrieved in our literature search evaluated the usefulness of FDG-PET/CT as a follow-up study whole body examination to conventional cross-sectional imaging for the detection of unexpected distant metastases. One of the challenges encountered in evaluating the studies, is that often distant metastases (liver, peritoneal, lung, bone, nodes) were put together into a single group rather than subgroups by the type of distant metastasis. The results are variable across studies with the detection rate of unexpected distant metastases generally identified in patients as probably resectable based on contrast-enhanced CT or MRI, ranging from 2.5% to 41% [43-48]. A recent meta-analysis of FDG-PET/CT imaging (4 studies, 101 patients) showed a pooled sensitivity of 64% and specificity of 81% for metastatic nodal disease, and a sensitivity of 67% and specificity of 96% for liver metastases [49].

Variant 2: Pancreatic ductal adenocarcinoma. Follow-up post-neoadjuvant therapy. Evaluate resectability for borderline resectable tumor.

Only five articles that addressed the topic of preoperative therapy in the context of staging a tumor were identified in the literature search.

CT

Only very limited information is available regarding staging in the setting of preoperative chemotherapy and/or radiation therapy. Challenges include differences in treatment regimens. A small study comparing 31 patients who had undergone neoadjuvant therapy (between 2005 and 2010) for locally advanced disease that went on to attempted curative resection with a control group of 41 patients who went directly to surgery showed that the accuracy of MDCT (in this study, 16- and 64-detector row) for determining resectability was significantly less in the neoadjuvant group (58% versus 83%), primarily secondary to an overestimation of vascular invasion [50]. This study was limited by a mix of treatment regimens including chemotherapy alone, radiation therapy alone, and combination chemoradiation. Other studies have also shown that imaging signs of vascular involvement by tumor persist even after successful therapy because of the inability of imaging to distinguish viable from nonviable tumor [51,52]. No information was available from our search in regard to the accuracy of identifying nodal metastases, liver metastases, or peritoneal disease in the setting of neoadjuvant therapy.

MRI

The literature search did not identify any studies that examined the accuracy of MRI in the assessment of staging following preoperative therapy.

EUS

The literature search did not identify any studies that examined the accuracy of EUS in the assessment of vascular involvement by tumor following neoadjuvant therapy.

US

The literature search did not identify any studies that examined the accuracy of transabdominal US in the assessment of vascular involvement by tumor following neoadjuvant therapy.

FDG-PET/CT

The literature search did not identify any studies that examined the accuracy of FDG-PET/CT in the assessment of staging following neoadjuvant therapy.

Reporting of Imaging Findings for Staging Pancreatic Cancer

An emerging issue has been the reporting of findings for staging for pancreatic cancer by radiologists, namely, the usefulness of structured reporting or template reporting versus free-form (nonstructured) dictation. A single institution study had surgeons evaluate 48 structured and 72 nonstructured reports and found that information for surgical planning was readily accessible in 60% to 98% of structured reports, but only 32% to 54% in nonstructured reports [53]. In a retrospective study of 200 reports reviewed by radiologists, it was noted that in 20.3% of reports, resectability status could not be determined based on the report alone [54].

Societies such as the American Pancreatic Association, the Society of Abdominal Radiology, and the Radiological Society of North America have made resources available with regard to guidelines and templates for reporting [55,56]. In brief, these guidelines incorporate descriptions of the morphology and size of the primary tumor, its effect on ducts, descriptions of extension beyond the pancreas, descriptions of involvement of vascular structures using standardized terminology (degrees of circumferential involvement, or the words "abutment" for up to 180° of vessel involvement or "encasement" for greater than 180° of involvement), descriptions of sites of suspicious nodes based on size criteria or morphology, and findings on the inspection of typical sites of metastatic spread (liver, peritoneum, lung, and bone) [55,56].

Summary of Recommendations

- Pancreatic adenocarcinoma is often diagnosed at advanced disease stage with poor prognosis. Surgical advances in conjunction with combination systemic therapies and radiation therapy have been suggested to improve outcomes. Shifts in treatment approach, particularly attempts to increase surgical candidacy, have been driven by complete surgical resection being the only possible option for cure. Sophisticated vascular surgery is performed to remove sites of potential perineural tumor spread. Such changes have resulted in not only considering patients with resectable tumor but also borderline resectable tumor as surgical candidates.

From a radiology perspective, this has translated into an expectation of greater report detail and specifics. Beyond identification of metastatic disease, appropriate description of extent of involvement of key vascular structures (especially SMA), tumor size (whether 2 cm or smaller), and location is required.

- MDCT with arterial and portal venous phase imaging and dynamic contrast-enhanced MRI are recommended for primary staging. Although preference tends to reflect institutional experience and practice, MDCT is preferred by many. EUS and FDG-PET/CT can be useful problem-solving techniques for biopsy guidance and confirmation of distant metastases, respectively.

- Limited data are available regarding accuracy of imaging for preoperative staging following chemotherapy and/or radiation therapy. Varied treatment regimens present a particular challenge in assessing vascular involvement, and performance of state-of-the-art MDCT or MRI for determining resectability is compared to patients going straight to surgery.

Summary of Evidence

Of the 57 references cited in the ACR Appropriateness Criteria® *Staging of Pancreatic Ductal Carcinoma* document, 14 are categorized as therapeutic references including 5 well-designed studies, 5 good-quality studies, and 1 quality study that may have design limitations. Additionally, 37 references are categorized as diagnostic references including 6 good-quality studies, and 14 quality studies that may have design limitations. There are 20 references that may not be useful as primary evidence. There are 6 references that are meta-analysis studies.

The 57 references cited in the ACR Appropriateness Criteria® *Staging of Pancreatic Ductal Carcinoma* document were published from 1985 to 2017.

Although there are references that report on studies with design limitations, 16 well-designed or good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional

information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [57].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
⭘	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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