INTRODUCTION

Fine-needle aspiration and small-core biopsy of the pancreas are now the standard of care for the sampling of pancreatic masses. Wedge biopsy of the pancreas at the time of laparotomy was the traditional method of sampling the pancreas until the introduction of needle-core biopsy in the 1950s. The first needle type was the Vim-Silverman needle, which was typically used under direct palpation by the surgeon at the time of laparotomy. The advantages were better sampling, and access to deeply seated lesions; however, the complication rate was reportedly worse compared to wedge biopsy, probably because the needle sampled deeper lesions. Both were associated with hemorrhage, pancreatitis, fistulas, abscess formation, and death.

The first reports on fine-needle aspiration biopsy (FNAB) of the pancreas came from Sweden in 1970, performed on autopsy samples and preoperatively on live patients. Preoperative FNAB was found to be safer than core biopsies and more accurate than wedge excisional biopsy, and, thus, for years was the preferred method of confirming the diagnosis of pancreatic carcinoma before definitive surgical intervention. No false positives were reported.

The next advance came with the development of image-guided FNAB. The first percutaneous image-guided biopsy was performed under angiography and reported in 1972. In 1975, transabdominal ultrasound was reported to guide FNAB. Computed tomography (CT) was reported in 1976 and endoscopic retrograde cholangiopancreatography was used in 1978. Endoscopic ultrasound was introduced in the 1990s, and now is the most frequently used modality to guide FNAB of the pancreas, followed by CT scan (see Chapter 2). FNAB is recognized as a safe and effective means of sampling the pancreas.

ALGORITHMIC APPROACH TO THE INTERPRETATION OF PANCREATIC FNAB

The interpretation of a pancreatic FNAB should begin with knowledge of the clinical and imaging findings. From an imaging standpoint, lesions of the pancreas are broadly divided into cystic lesions, solid lesions, and solid and cystic lesions. The imaging appearance determines the differential diagnosis and algorithmic approach to biopsy evaluation (Figure 1.1), making the imaging findings the most critical piece of information to have before assessing the biopsy sample. The differential diagnosis for solid masses includes a number of neoplastic processes, such as neuroendocrine tumors, acinar cell carcinomas, and pancreatic ductal adenocarcinomas (Table 1.1). The imaging characteristics of the solid mass are also very helpful in further refining the differential diagnosis. Adenocarcinomas are hypoechoic masses with irregular borders, whereas the other solid tumors are rounded masses with well-defined borders. The differential diagnosis for cystic lesions includes pseudocysts, developmental cysts, and cystic neoplasms (Table 1.2). The characteristics of the cyst are also helpful in further refining this differential diagnosis. For example, a lobulated mass composed of numerous small microcysts and a central stellate scar is virtually pathognomonic of a serous cystadenoma and a septated cyst is very unlikely to be a pseudocyst (see Chapter 7). It should always be remembered that any solid mass may undergo cystic degeneration secondarily and present as a cystic mass, usually a solid and cystic mass. A solid pseudopapillary neoplasm typically presents as a solid and cystic mass.

GUIDELINES FOR PANCREATOBILIARY CYTOLOGY REPORTING TERMINOLOGY

The Papanicolaou Society of Cytopathology (PSC) recently published guidelines for pancreaticobiliary cytology which
address indications, techniques, terminology and nomenclature, ancillary studies, and postprocedure management. The guidelines were drafted by committees composed of a group of multidisciplinary experts in diagnosing, managing, and treating patients with pancreaticobiliary disease. The proposed Pancreaticobiliary Terminology classification scheme has six categories (Table 1.3). While a terminology classification is not absolutely necessary for all cytological diagnoses (in other words, the diagnosis of adenocarcinoma does not need an interpretation category of “positive or malignant”), some laboratory information systems require such a category. If a category is going to be used, the system proposed by the PSC offers a standardized method that can be universally understood while offering a reporting system for maximum flexibility in patient management. One caveat is that the clinical and imaging findings should

Table 1.1 Differential diagnosis of solid masses.

<table>
<thead>
<tr>
<th>Benign/non-neoplastic</th>
<th>Neoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancreatitis</td>
<td>Ductal adenocarcinoma</td>
</tr>
<tr>
<td>Acute</td>
<td>Neuroendocrine tumors</td>
</tr>
<tr>
<td>Chronic</td>
<td>Acinar cell carcinoma</td>
</tr>
<tr>
<td>Autoimmune</td>
<td>Pancreatoblastoma</td>
</tr>
<tr>
<td>Ectopic spleen</td>
<td>Metastases</td>
</tr>
</tbody>
</table>

Table 1.2 Differential diagnosis of cystic masses.

<table>
<thead>
<tr>
<th>Benign/non-neoplastic</th>
<th>Neoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphoepithelial cyst of the pancreas</td>
<td>Serous cystadenoma</td>
</tr>
<tr>
<td>Squamous cyst of pancreatic ducts</td>
<td>Mucinous cystic neoplasm</td>
</tr>
<tr>
<td>Dermoid cyst</td>
<td>Intraductal papillary mucinous neoplasm</td>
</tr>
<tr>
<td>Squamoid cyst in ectopic spleen</td>
<td>Intraductal papillary oncocytic neoplasm</td>
</tr>
</tbody>
</table>

Table 1.3 PSC reporting terminology categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Nondiagnostic</td>
</tr>
<tr>
<td>II</td>
<td>Negative for malignancy</td>
</tr>
<tr>
<td>III</td>
<td>Atypical</td>
</tr>
<tr>
<td>IV</td>
<td>Neoplastic</td>
</tr>
<tr>
<td>V</td>
<td>Suspicious for malignancy</td>
</tr>
<tr>
<td>VI</td>
<td>Diagnostic for malignancy</td>
</tr>
</tbody>
</table>

Figure 1.1 Algorithmic approach to the evaluation of pancreatic masses based on whether they are solid, solid and cystic, or cystic. This will guide the differential diagnosis and, therefore, the clinical management decisions.
always be taken into consideration when determining the adequacy and categorization of a sample. The categories, as they pertain specifically to pancreatic FNAB, are described as follows.

Category I. Nondiagnostic. This category is used when the sample provides no diagnostic or useful information. An example would be an acellular cyst fluid that lacks background mucin and on which ancillary testing was not performed. Another example is an aspirate of a solid mass with only gastrointestinal contaminant. As for any cytology specimen, any aspirate with cytological atypia cannot be classified as nondiagnostic regardless of other factors.

Category II. Negative for malignancy. A sample deemed negative for malignancy contains adequate cellular and/or extracellular material to evaluate a mass identified on imaging studies. A definitive diagnosis should be rendered whenever possible, but is not always possible. In such cases, a description of the cytological findings is appropriate. For example, an aspirate of benign pancreatic tissue in the setting of a vague abnormality or irregularity is negative for malignancy. Another example is nonspecific cyst debris with low carcinoembryonic antigen (CEA) and amylase levels, which may well be representative of a pseudocyst, but the absence of characteristic morphology (see Chapter 7) and absence of documented pancreatitis preclude such a specific diagnosis.

Category III. Atypical. This category applies when cells are identified that have architectural, cytoplasmic or nuclear features that are not normal, but are insufficient for classification as a neoplasm or suspicious for malignancy. These include atypical reactive changes, low cellularity specimens, and specimens with atypical/dysplastic changes outside of a defined neoplasm. Aspirates suspected of being a neuroendocrine tumor without diagnostic cytomorphology or insufficient tissue for confirmatory ancillary testing are placed in the atypical category.

Category IV. Neoplastic. This category is subdivided into benign and other.

Benign. This category is used for specimens containing material diagnostic of a neoplasm that is known to behave in a benign fashion. The primary lesion in this category is serous cystadenoma.

Other. This category is used for pre-invasive, pre-malignant neoplasms, such as intraductal papillary mucinous neoplasm and mucinous cystic neoplasm, and low-grade neoplasms regardless of malignant potential, such as pancreatic neuroendocrine tumor and solid pseudopapillary neoplasm. This category was the most controversial aspect of the terminology proposal, as both pancreatic neuroendocrine tumors and solid pseudopapillary neoplasms are considered “malignant”. However, this category was devised to relate the cytological category to the WHO 2010 classification that maintains the nomenclature of tumor and neoplasm for these entities, to separate these low-grade neoplasms from the usual high-grade and aggressive ductal carcinoma, and to take into consideration the increasingly conservative management approaches for small neuroendocrine tumors in some patients.

Category V. Suspicious for malignancy. A specimen is considered suspicious for malignancy when some but not all of the features of a specific high-grade malignancy are present. An example would be cytology suspicious for ductal carcinoma or suspicious for an acinar cell carcinoma with insufficient tissue for immunohistochemical confirmation.

Category VI. Positive for malignancy or malignant. This includes neoplasms with unequivocal malignant features including pancreatic ductal carcinoma, acinar cell carcinoma, lymphoma, metastases, and sarcomas.

**WORK-UP AND MANAGEMENT OF THE PATIENT PRESENTING WITH A PANCREATIC MASS**

The management of a patient presenting with a pancreatic mass should involve a team approach with input from surgeons, gastroenterologists, medical and radiation oncologists, radiologists, and pathologists. Assessment includes clinical evaluation, patient and family history, laboratory tests, serum tumor markers, and imaging modalities.

**Clinical and patient and family history**

Presenting symptoms and signs could indicate a tumor-associated syndrome. Examples include hormonal syndromes associated with functional pancreatic neuroendocrine tumors, lipase hypersecretion syndrome associated with acinar cell carcinoma, or paraneoplastic syndromes...
CHAPTER 1

associated with poorly differentiated neuroendocrine carcinomas. Patient history provides information on risk factors, genetic syndromes predisposing to certain neoplasms, and previous history of malignancy. Family history provides information on whether the patient has family members with a previous history of carcinoma or other malignancies, which could suggest a genetic predisposition to pancreatic carcinoma.

Serological studies
Elevated serum lipase levels could determine if the patient has a lipase-secreting acinar cell carcinoma, even if the patient does not have the signs and symptoms of a lipase-hypersecreting syndrome. Chromogranins are a family of glycoproteins belonging to the granin family of proteins, which also includes the secretogranins found in the secretory granules of endocrine and neuroendocrine cells. Plasma chromogranin A (CgA) is the most useful marker for diagnosing and monitoring patients with neuroendocrine tumors, including pancreatic neuroendocrine tumors. Limitations to the use of CgA as a biomarker include treatment with proton-pump inhibitors, chronic atrophic gastritis-impaired renal function, and inflammatory bowel disease. Serum pancreatic polypeptide levels are used less frequently due to lower sensitivity, but when used in combination with CgA can improve sensitivity to 93%.

Hypersecretion of insulin is seen with insulinoma, which is associated with hypoglycemia (confusion, lethargy, seizures); hypersecretion of gastrin is seen with gastrinoma, which produces the Zollinger–Ellison syndrome (recurrent peptic ulcer disease, diarrhea, and weight loss); hypersecretion of glucagon is seen with glucagonoma, which is characterized by necrolytic migratory erythema, cheilitis, weight loss, glucose intolerance, venous thrombosis, and diarrhea; and hypersecretion of vasoactive intestinal polypeptide (VIP) is seen with VIPoma, which is associated with a syndrome of watery diarrhea and hypokalemia.

Serum tumor markers
CA 19-9 is the tumor marker most commonly used in the evaluation of pancreatic ductal adenocarcinoma (PDAC). The CA 19-9 antigen is a sialylated oligosaccharide that is normally present within the cells of the biliary tract. The normal reference range for CA 19-9 is 0–37 U/ml. Up to 75–85% of patients with PDAC present with elevated CA 19-9 levels. False positives occur due to biliary disease, liver disease, acute and chronic pancreatitis, cystic fibrosis, or thyroid disease. CA 19-9 is not specific for PDAC, as it can be elevated in other cancers. The sensitivity and specificity depend on the cut-off levels employed. A cut-off level of 100 U/ml has a sensitivity of 68% and a specificity of 98% in the absence of other factors, such as biliary tract disease. CA 19-9 is of greatest utility in the staging and follow-up of patients with PDAC, and is used to monitor response to therapeutic interventions. An increasing CA 19-9 following resection, chemotherapy or radiation therapy suggests progressive disease.

Carcinoembryonic antigen (CEA) is a high-molecular-weight glycoprotein found normally in fetal tissues commonly used as a tumor marker in other gastrointestinal malignancies. The reference range is 0–2.5 mg/ml. Because CEA is elevated in many gastrointestinal malignancies, and only 40–45% of patients with PDAC have an elevated CEA, it is of limited usefulness for the monitoring of patients with PDAC.

Alpha-fetoprotein (AFP) is a glycoprotein normally produced in fetuses by the liver, yolk sac, and gastrointestinal tract. The normal range for healthy adults and non-pregnant females is 0–10 µg/l. AFP may be elevated in up to 20% of patients with acinar cell carcinoma, and therefore may be used as a marker to monitor the effect of therapy and recurrence in these patients.

Imaging modalities
Current imaging modalities used to evaluate pancreatic lesions include: transabdominal ultrasound (TUS), endoscopic ultrasound (EUS), computed tomography (CT), magnetic resonance imaging (MRI) and occasionally positron emission tomography (PET). These modalities have different strengths and weaknesses. EUS will be discussed in detail in Chapter 2.

Transabdominal ultrasound (TUS) is no longer routinely used for assessing patients with pancreatic masses, although it may be useful in distinguishing solid from cystic pancreatic lesions. For solid lesions, TUS may detect the lesion and can visualize obstruction of the main pancreatic duct (MPD). However, TUS has certain limitations. It can be difficult to visualize the entire pancreas. Overlying bowel gas may obscure the pancreas and image quality may be degraded in obese patients. In addition, TUS has lower
spatial resolution than other modalities. TUS is not adequate for preoperative staging to evaluate involvement of the adjacent vascular structures and organs. For cystic masses, TUS can characterize the internal features of the cysts under the right circumstances. However, TUS has limitations for the evaluation of cystic masses. It may be difficult to determine the exact relationship of the lesion to the MPD. The characterization of internal contents may also be difficult using TUS. For example, it may be difficult to distinguish a mural nodule from debris or a blood clot in a lesion. It may also be difficult to distinguish a microcystic lesion from a solid lesion. Despite these limitations, TUS is a quick, inexpensive, and widely available modality that can detect lesions and narrow the differential diagnosis. The caveat is that findings detected with TUS usually require further evaluation with CT or MRI.

Computed tomography is the main modality used in the evaluation of the pancreas. CT provides high-resolution images that can distinguish solid from cystic pancreatic lesions and determine the relationship of these lesions to adjacent structures. A typical CT (pancreas protocol) to evaluate a pancreatic lesion will consist of high-resolution (typically 3-mm slice thickness or less) multiplanar images and multiphase postcontrast images (noncontrast, arterial, and venous phases). The high-resolution images are necessary to evaluate small structures and their relationship to the adjacent vasculature and the MPD. Multiplanar images, typically acquired in axial, coronal and sagittal planes, are crucial in this application. Contrast is necessary to opacify the vessels and postcontrast images are acquired at different times to provide optimal enhancement of the pancreas, arteries, and veins. The postcontrast characteristics of a lesion may narrow the differential diagnosis. For example, lesions with avid early enhancement include neuroendocrine tumors and metastases from renal cell carcinoma (Figure 1.2). In contrast, pancreatic adenocarcinoma exhibits hypoenhancement relative to normal pancreatic parenchyma (Figure 1.3). Contrast will help identify enhancing mural nodules or complex internal architecture in cystic pancreatic lesions that indicate dysplasia or malignancy (Figure 1.4).

Although CT is the main modality used for imaging the pancreas, MRI can provide useful information in certain cases, especially in the evaluation of cystic pancreatic lesions. Pancreas protocol MRI is emerging at some centers as an equivalent alternative to CT. MRI images are also acquired in multiple planes (typically axial and coronal) and provide high-resolution images. T2-weighted images are the main MRI sequence used in the evaluation of cystic pancreatic lesions. Lesions which contain fluid or mucin have high contrast from pancreatic parenchyma and adjacent structures on T2-weighted images, even without the administration of intravenous contrast. MRI also utilizes postcontrast images to evaluate the internal architecture of cystic lesions to exclude solid internal components, a high-risk feature for malignancy.
Typically an MRI to evaluate a cystic pancreatic lesion will include magnetic resonance cholangiopancreatography (MRCP). MRCP utilizes special parameters to acquire high-contrast, multiplanar, high-spatial resolution images of the biliary system and main pancreatic duct (Figure 1.5). It allows very accurate delineation of the internal architecture of cystic pancreatic lesions and their relationship to the MPD. These features are very important in narrowing the differential diagnosis of cystic pancreatic lesions. For example, the microcystic internal architecture of a serous cystadenoma can be distinguished from the larger cystic locules of a mucinous cystic neoplasm. Another example is the identification of the cyst communicating with the MPD, a key feature of an intraductal papillary mucinous neoplasm (IPMN).

Positron emission tomography (PET) uses 18F-fluorodeoxyglucose (FDG) to image the primary tumor and metastatic disease. PET scanning appears to be most useful for the imaging of metastatic disease. Its role in the work-up of the primary mass is not as evident. Studies of PET-CT have suggested that PET-CT scanning is more sensitive than conventional imaging for the detection of pancreatic cancer and that PET-CT scan findings sometimes change clinical management. The National Comprehensive Cancer Network (NCCN) guidelines consider PET-CT an evolving technology, its role in the diagnosis of pancreatic cancer is not yet established.

The imaging evaluation of neuroendocrine tumors (NETs) deserves special attention because there are functional imaging methods that can be employed when imaging these tumors. Radiolabeled somatostatin analogs can be used to image NETs by binding to somatostatin receptors. $^{111}$In-pentetreotide (OctreoScan) was one of the first functional imaging methods used in the evaluation of NETs (Figure 1.6). In addition to localizing the primary tumor and metastases, $^{111}$In-pentetreotide can be used to plan treatments and monitor therapy response. $^{111}$In-pentetreotide has low sensitivity for small (<1 cm) and dedifferentiated tumors. A more recent development is the imaging of NETs with gallium-labeled somatostatin analogs. The somatostatin analogs are linked to $^{68}$Ga by a chelate. One of the more commonly used chelates is 1,4,7,10-tetraazacyclododecane-1,4,7,10-tetraacetic acid (DOTA). The three main $^{68}$Ga–DOTA-labeled somatostatin analogs currently in use are DOTA-NOC, DOTA-TATE, and DOTA-TOC. $^{68}$Ga-DOTA uses PET-CT rather than SPECT (single photon emission computed tomography) and has several advantages over imaging with $^{111}$In-pentetreotide including: faster image acquisition, improved spatial resolution, higher affinity for somatostatin receptors and the ability to quantify activity. $^{68}$Ga–DOTA-labeled somatostatin analogs are useful for detecting primary lesions and the site of metastatic disease, as well as planning and monitoring response to therapy. A pitfall to the $^{68}$Ga–DOTA-TATE PET-CT scan, however, is the potential false-positive results with high uptake in the...
uncinate process due to the high concentration of somatostatin receptors in this location, especially in the setting of endocrine hyperplasia and aggregation.

**THE ROLE OF IMAGING STUDIES IN THE WORK-UP AND MANAGEMENT OF PANCREATIC MASSES**

The primary roles of imaging in the preoperative work-up of pancreatic masses are to define the nature of the lesion, identify high-risk features in cystic masses, and assess resectability.

**Solid masses**

When a solid mass is identified by imaging, the main objective is to determine if the mass represents adenocarcinoma, mass-forming pancreatitis, or another solid pancreatic lesion. There are certain imaging features which are characteristic of pancreatic adenocarcinoma, but again a definitive diagnosis may be difficult by imaging alone. Adenocarcinoma typically appears as a mass that obstructs the main pancreatic duct and is hypoenhancing relative to normal pancreatic parenchyma (Figure 1.7). However, this appearance is not entirely specific for adenocarcinoma. For example, metastases to the pancreas may appear hypovascular and obstruct the MPD (excluding renal cell carcinoma metastases which are hypervascular). So although current imaging techniques can provide excellent anatomic detail, in many cases lesions remain indeterminate utilizing imaging alone.

CT is the standard for staging and assessing the resectability of pancreatic adenocarcinoma. This is because accurate staging and treatment of pancreatic adenocarcinoma requires exact analysis of the relationship of the mass to adjacent vascular structures. The resectability of a tumor depends on its relationship to the superior mesenteric artery, celiac axis, common hepatic artery, main portal vein, and superior mesenteric vein (SMV). If imaging reveals clear fat planes between these vessels and tumor, the lesion is considered resectable (Figure 1.7). A tumor that involves greater than 180 degrees of these arteries is considered to be locally advanced disease (Figure 1.8). Venous tumor involvement may be more extensive before it is considered locally advanced because venous reconstruction can be performed during surgery. If there is involvement of the main portal vein or SMV that is not deemed reconstructible, then that tumor is locally advanced. Other tumors (those with arterial involvement less than 180 degrees and venous involvement that is minimal or reconstructable) are considered borderline resectable (Figure 1.9). These patients may undergo neoadjuvant therapy followed by re-imaging to determine if the tumor was downstaged after therapy. A meta-analysis of 1823 patients with pancreatic cancer showed the sensitivity and specificity of helical CT...
to be 81% and 82%, respectively, for determining resectability, and also demonstrated that CT was superior to both MRI and US. Most patients only require CT scans as part of their work-up. It is important to note that while a definitive diagnosis of a mass lesion is not required prior to resection, it is required prior to instituting chemoradiation therapy.

Staging pancreatic cancer also requires evaluation of the patient for metastatic disease. Common sites of metastatic disease (liver metastases and abdominal lymphadenopathy) are easily detected and characterized by CT. MRI may be used as a problem-solving tool for indeterminate liver lesions or as an adjunct in high-risk patients in whom no metastases are identified initially. CT is also the modality of choice to exclude pulmonary metastases at initial staging.

PET-CT utilizing FDG is used in some centers in the staging of pancreatic cancer. PET-CT does have a relatively high sensitivity for distant metastatic disease, but will detect disease not already identified by CT in only a minority of cases. Work is ongoing determining the utility of PET-CT to evaluate response to therapy and to better distinguish benign from malignant processes.

Cystic masses

The imaging features of the most common cystic pancreatic lesions overlap. Therefore, it can be difficult to make a definitive diagnosis of a cystic pancreatic lesion by imaging alone (Figures 1.10 and 1.11). This is particularly true when a pancreatic pseudocyst is a possibility, as the imaging features of a pseudocyst can overlap with neoplastic pancreatic lesions. There are some imaging features that do help clinch a specific diagnosis. For example, the microcystic appearance of a serous cystadenoma has an imaging appearance that is fairly pathognomonic. Communication with the main pancreatic duct is a key feature of IPMN (Figure 1.11). Imaging can also help distinguish a side-branch IPMN from an IPMN with involvement of the MPD. Imaging evaluation of cystic pancreatic lesions must include a detailed analysis of the internal architecture of the
INTRODUCTION

lesion and the MPD to identify these features and others that help narrow the differential diagnosis. The role of imaging in the work-up of pancreatic cystic lesions is further discussed in Chapter 7.

PERCUTANEOUS IMAGE-GUIDED BIOPSY OF THE PANCREAS

Percutaneous image-guided needle pancreatic biopsy is a well-established method for obtaining tissue specimens for the diagnosis of pancreatic masses. Image-guided biopsy is indicated to establish a malignant diagnosis, either primary or metastatic, establish a benign diagnosis, or obtain material for culture or other laboratory studies. Image guidance provides safe access and needle passage into the targeted lesion for cytologic or histologic evaluation. In addition, the requests to obtain tissue for additional studies including molecular testing and to meet requirements for clinical trials may increase the demand for these procedures than has been required traditionally.

Image-guided biopsy can be performed as an outpatient procedure, which is less invasive with lower morbidity, mortality, and cost compared to open biopsy techniques. Successful diagnosis of a lesion depends on several factors. For image-guided needle biopsy these factors include whether the target lesion is amenable to a percutaneous image-guided approach, the technical expertise of the radiologist and cytopathologist, and proper specimen preparation. On-site evaluation of FNAB specimens by a cytopathologist is important as this increases diagnostic yield and accuracy of needle biopsies of the pancreas (see below).

PERCUTANEOUS BIOPSY

Percutaneous biopsy of the pancreas can be performed with a variety of imaging modalities. They include multidetector CT, ultrasonography (US), MRI, and fluoroscopy. The predominant image-guidance modalities remain CT and US. As with the biopsy of other abdominal lesions, CT- and US-guided biopsy of the pancreas has been the mainstay of minimally invasive needle biopsy prior to the introduction of endoscopic US-guided biopsy of the pancreas. MR-guided needle biopsy of retroperitoneal lesions including the pancreas has also been performed safely and accurately and can be an alternative to CT- or US-guided biopsies when lesion detection by MRI is more favorable. The role of any image-guidance technique is to identify the target, identify a safe route of access, identify the entry site and distance to the target along a safe access route, and to confirm the proper position of the needle tip within the target during the biopsy procedure.

In addition to standard imaging techniques, additional imaging-guidance techniques are available. CT fluoroscopy utilizes rapid sequential CT imaging at a fixed table position to view the needle during needle manipulation. This can increase the accuracy of needle placement and reduce procedure time. Although this can reduce the radiation dose to the patient, it has the disadvantage of potentially increasing the radiation exposure to the operator. Navigation guidance technology utilizing electromagnetically tracked needles in combination with real-time US or fused CT imaging have been used to visualize a path and track needle position during needle advancement providing greater precision in needle placement. This is particularly helpful in more complex off-axis approaches to reach the target. This has been shown to reduce both needle placement times and the number of needle pullbacks needed for redirection during the biopsy. Although needle tracking navigation systems are commercially available, in routine practice they are not commonly used because they require additional time for equipment setup which may offset the time saved during the procedure as well as the added expense to the procedure.

NEEDLE TYPES

There are a variety of needle types available for image-guided biopsies. FNAB needles typically range from 19 to 25 g and may be beveled or non-beveled. These include non-beveled Greene®, and beveled Chiba®, Franeseen®, and Westcott® needles, among others. They come in standard lengths of 9, 15, and 20 cm. In comparison to core-biopsy needles, FNAB needles have the potential benefit of being safer with the ability to traverse bowel or even vascular structures, but this also requires the availability of good cytology with on-site monitoring by a cytotechnologist or cytopathologist. A coaxial 18- or 19-gauge thin-wall guide needle is often used to aid in obtaining multiple samples without the need to repeat image-guided biopsy needle placement each time. A beveled tip may make it harder to hit the target due to deflection of the needle path. However, it can also be used to its advantage to “steer” the needle
based on bevel orientation. A prospective study to evaluate the effect of four different FNAB needle tip configurations on the diagnostic yield of tissue samples in abdominal lesions showed some variability, including yield from the pancreas. However, no one particular aspiration needle was clearly superior to another for the biopsy of pancreatic masses.

Core needles typically used for the pancreas are 18–20 gauge “Tru-cut” type needles with 1 or 2 cm “throw”, which is the length of extension of the inner stylet from the outer cutting cannula. The length of the specimen notch within the inner stylet is slightly shorter than the throw of the inner stylet. An example of this type of core needle is the Quick-core® needle. Spring-loaded automated biopsy gun-type core needles are also commonly used. Compared to FNAB, core biopsy has the advantages of obtaining better definitive benign diagnosis, and faster procedure time without the need for on-site monitoring. However, there can be

Figure 1.10 These CT and MR images show a cystic lesion in the pancreas but the appearance is nonspecific. Differential possibilities include IPMN, mucinous cystic neoplasm, pseudocyst or more rare cystic lesions. (A) Axial contrast-enhanced CT image shows a small cystic lesion in the head of the pancreas. (B) Axial T2-weighted image from an abdomen MRI shows the cystic lesion. No internal mural nodularity is identified. (C) MRCP image from an abdominal MRI shows the cystic lesion without complex internal architecture.