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Ultrasonography of the pancreas. 5. Interventional procedures

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Abstract

Interventional ultrasonography (US) is often used for the diagnosis and therapy of pancreatic pathologies, and its diffusion has definitelymodified the diagnostic and therapeutic management of some diseases. US is particularly suitable for targeting percutaneous pancreatic interventionalprocedures and important technical features contribute to this result. First of all, US is dynamic, and thus the ongoingprocedure can be continually monitored. Then, the high spatial resolution achieved by US imaging in recent years, its speedand availability and the low-cost of the technique, together with the technical features, have ledto an ever-increasing use of US in pancreatic interventional procedures. This article will review the application of US as guide ofdiagnostic and interventional procedures in the different pancreatic pathologies.

Key words: Pancreatic biopsy—Percutaneous drainage—Pancreatic tumors—Pancreatic infections—Pancreatic pseudocyst

Interventional ultrasonography (US) is often used for the diagnosis and therapy of pancreatic pathologies [1–5], and its diffusion has definitely modified the diagnostic and therapeutic management of some diseases [5–7]. US is particularly suitable for targeting percutaneous pancreatic interventional procedures, and important technical features contribute to this result. First, US is dynamic, and thus the ongoing procedure can be continually monitored. Second, the high spatial resolution achieved by US imaging in recent years, its speed and availability, and the low-cost of the technique, together with the technical features, have led to an ever-increasing use of US in pancreatic interventional procedures. In clinical practice, obtaining the best results in US-guided procedures depends on the available materials and on the experience of the operator.

Technical background

In US-guided procedures, compared to what often happens in computed tomography (CT) [8], entry points to the pancreatic gland are chosen more freely because of the possibility of immediate and easy oblique projections to access the gland, both craniocaudally and laterolaterally. As a result, the safest and therefore most used entry point, especially for diagnostic procedures, is the left upper quadrant, left of the midline. Through this access, the needle tract avoids important structures such as the gallbladder and the hepatic and gastroduodenal arteries, and the ideal track to reach the target point will be more or less angled, depending on its location in the pancreatic gland. Drawing on the US images two orthogonal axes intersecting on the superior mesenteric artery, the needle track will be more angled when reaching the isthmus or head of the pancreas and less angled when reaching the pancreatic body (Fig. 1). Progressive manual compression of the abdominal wall is associated with obliquing of the beam to obtain the safest entry point, often avoiding passage into hollow organs. While transgastric passage is not as uncommon, trans-colonic passage should be avoided. However, entry points for therapeutic interventional procedures, regarding the aforementioned, are chosen more freely and depend on each individual case.

Probes and guides

Two types of probes are used for interventional procedures: those with lateral support and those with non-continuous crystals and central support. Probes with lateral support have a lateral-mounted guide kit (Fig. 2). Due to technical limitations, a vertical track is not possible with this type of probe and the needle is always visualized in oblique tracks. The angle of the track is chosen from among the available options so as to reach

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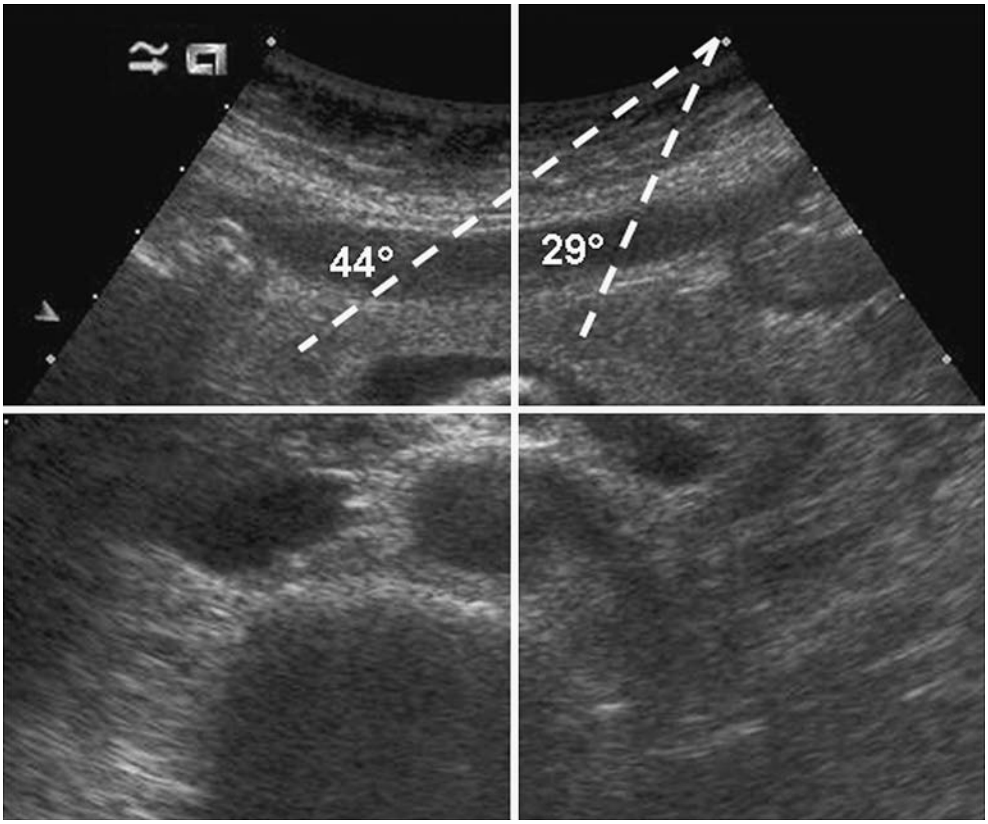

Fig. 1. US guide. Drawing on the US image of the pancreas, two orthogonal axes intersecting on the superior mesenteric artery, the needle track will be more angled (44°) when reaching the neck or head of the pancreas and less angled (29°) when reaching the pancreatic body.

Fig. 2. US guide. Convex probe (2–4 MHz) with lateral-mounted guide kit.

Fig. 3. US guide. Convex probe (2.5–5 MHz) for central guide kit.

the target in the safest possible way (Fig. 1). Probes with noncontinuous piezoelectric transducer crystals and central support have a centrally mounted guide kit. With these probes both vertical and oblique tracks can be used with a variable angle depending on the available options (Fig. 3). The guide kits mounted laterally or centrally are different in caliber (from 22 to 14 gauge [G]) and have different insertion points or positions, which correspond to the angle chosen according to the imaging.

Needles and catheters

Needles used in diagnostic interventional pancreatic procedures are different for cytological and bioptic samplings. Needles for fine-needle aspiration, with a 22- to 20-G caliber, have an internal stiletto which, depending on the type, may be removed so that the material rises due to capillarity or may function in aspiration to obtain suction material, the latter usually bigger (21–20 G) than the former (22–21 G).

Core-biopsy needles take a core of the pancreatic lesion with a suction mechanism—aspiration-type needles (Menghini-type needle)—or with a guillotine mechanism (Fig. 4A)—cutting-type needles (Trucut-type needle). The calibers vary from 22 to 16 G. Brandt et al have reported a 92% accuracy for biopsies performed with 16- to 19-G needles [2], whereas an accuracy of 85% has been reported for biopsies performed with 20- to 22-G needles [2]. Brandt et al reported that, in their series, both 18-G and thin-gauge needles caused minor complications and that the use of a thin, 21- or 22-G needle can still cause a major complication [2]. The probability of developing complications due to the size of the needle might be related to the sampling mechanism. A greater tissue trauma is expected when using a cutting-type needle rather than an aspiration-type needle. Complications reported in the literature for the former type are up to 19% [9], while those for the latter are always lower than 5% [4, 10, 11]. In some series, however, bioptic sampling led to a high diagnostic accuracy [2, 11, 12]. It therefore seems appropriate, in consideration of the complications due to tissue trauma in biopsy, to perform it only in those cases where cytological sampling is nonconclusive.

Drainage catheters differ in caliber and model according to the positioning technique, either Trocar or Seldinger. The Trocar technique is the best for US-guided procedures. Small-caliber (5.7-French [Fr]) catheters are inserted via the 14-G US guide for precise positioning in mainly fluid collections (Fig. 5). Larger catheters (8–10 Fr) are used for US-guided freehand insertions. When the subcutaneous drainage channel has consolidated, it is easier to position larger catheters with the Seldinger technique under fluoroscopic control. The size of the catheters used varies from 20–24 up to 30 Fr [8, 13].

Examination protocols

Fine-needle aspiration and biopsy

Patient preparation before a diagnostic interventional procedure on the pancreas includes ruling out coagulation disorders with laboratory tests and obtaining the patient's informed consent. The pancreatic lesion is then studied with conventional US, harmonic US, and Doppler US. The content and organization of the lesion (solid/fluid content, intralesional colliquation areas, lesional calcifications, and perilesional capsule) are evaluated to choose the best site for sampling.

Contrast medium administration might be useful, especially in the case of larger lesions, in order to be able to exactly position the tip of the needle in the viable portion of the lesion (Fig. 6). Doppler images are fundamental for the identification of primary and secondary perilesional arteries and veins (Fig. 7).

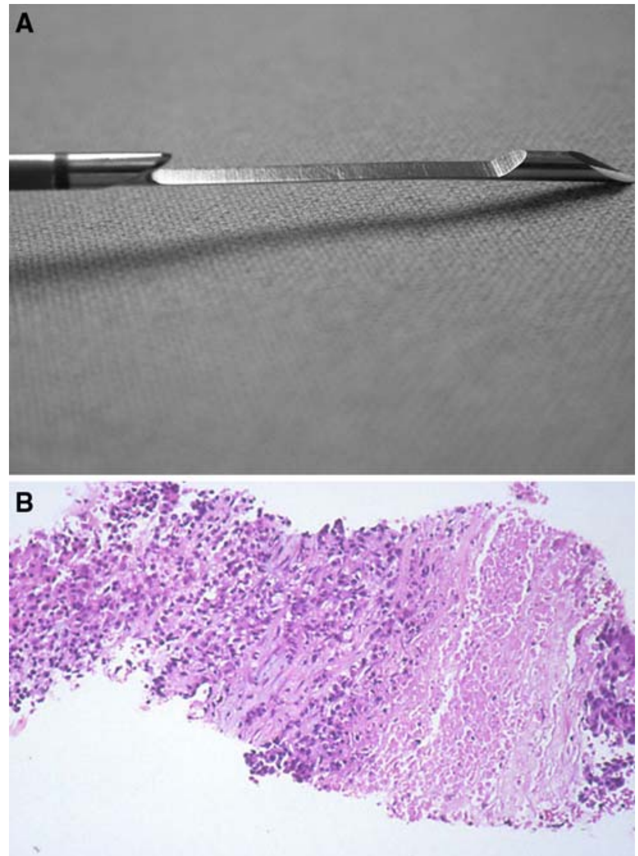

Fig. 4. Pancreatic biopsy. **A** Cutting-type needle (Trucut-type needle) with guillotine mechanism. **B** Bioptic specimen stained with hematoxylin/eosin, showing a poorly differentiated adenocarcinoma.

Local anesthesia is administered in the anterior abdominal wall at the chosen entry point. To perform cytological sampling once the pancreatic lesion has been reached, the needle is moved in and out with very small excursions from the center point. When suction has to be applied, a 10-mL syringe fitted for aspiration is applied to the needle.

The copresence of a cytologist allows for the immediate preparation and reading of the sample. Immediate response on the sampled material determines the subsequent steps of the diagnostic procedure: either repetition of the fine-needle aspiration or association with biopsy if the material is inadequate or termination of the procedure if the material is diagnostic.

Specimen preparation

Cytological samples are obtained with aspiration-type needles (Menghini-type needles). Disperse, unstructured material is collected in the capillary cavity of the needle and used for cytological examination. The sample obtained by aspiration (fine-needle aspiration cytology; FNAC) is usually a semifluid material, which is placed

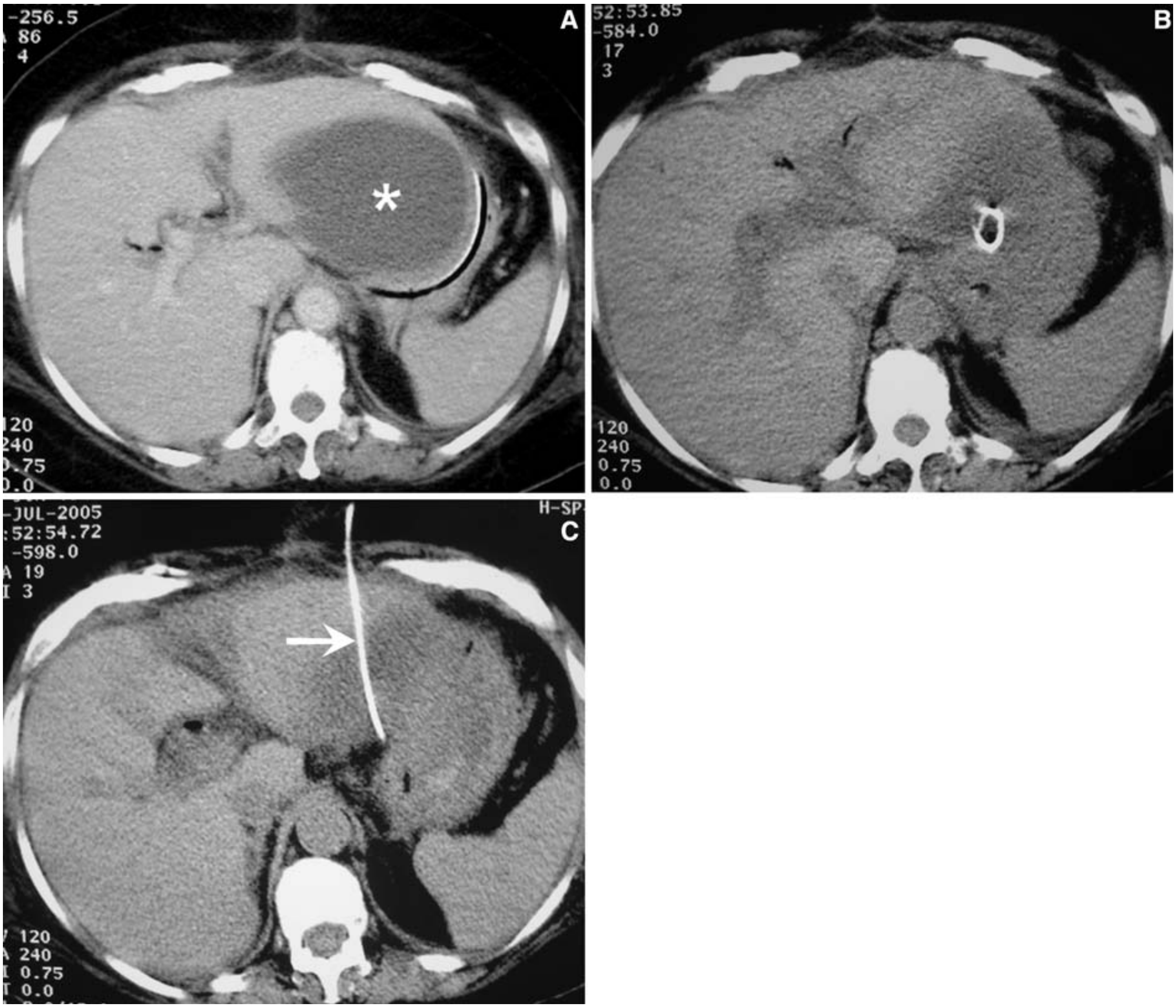

Fig. 5. Drainage of fluid collection. **A** Postoperative fluid collection (*asterisk*) displacing the stomach. **B**, **C** At CT control after US-guided transhepatic placement of a small (5.7-Fr) drainage (*arrow*), the fluid collection is reduced in volume.

on a glass slide. This material must contain little or no blood, as it can interfere with the viewing of the cells. Optimal reading of a cytological sample is possible when there is a single layer of cells, therefore the material must be immediately smeared into a thin layer and fixed to avoid cellular lysis and morphological artifacts. The type of fixation depends on the staining used. Staining may be performed on air-dried materials (e.g., Diff-Quick, MGG) or on alcohol-fixed material. The most commonly used fixation is 95% alcohol. Staining of the smeared material allows for examination at optic microscopy. The availability of fast stains that work in just a few minutes (Diff-Quick, shortened Papanicolau), means that the FNAC material can be evaluated immediately. The appropriateness of the material can therefore be judged in real time, and a cytological diagnosis can be obtained (Fig. 8A). When a morphological study with conventional stains is not sufficient for a definitive diagnosis, the same cytological sample can be used for immunohistochemical analysis for cellular typization (Fig. 8B).

Bioptic sampling is performed with aspiration-type needles (Menghini-type needles) or cutting-type needles (Trucut-type needles) to obtain a core of tissue for histological examination. The tissue samples are put in a tissue fixing solution, usually 10% neutral-buffered formalin, then included in paraffin, cut at microtome, stained with hematoxylin/eosin, and studied at microscopy (Fig. 4B). The preparation of a histological sample requires at least 2 days, and therefore the histological diagnosis and subsequent evaluation of the appropriateness of the material, as opposed to what happens in cytological examination, cannot be performed in real time. This may lead to the risk of false-negative results or inadequate material and the biopsy may need to be repeated quite quickly, thus complicating patient management. The availability of a diagnostic histological fragment, however, means that many more examinations

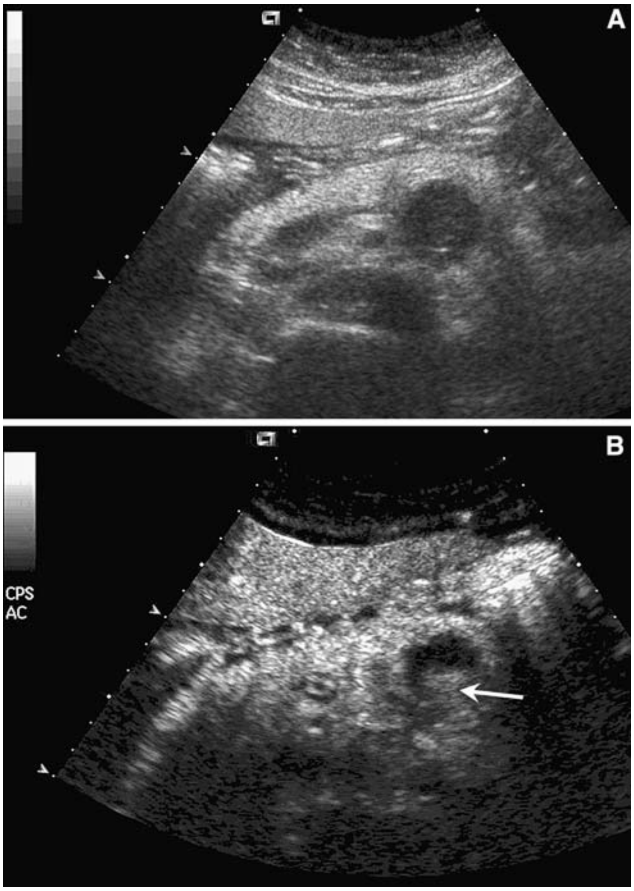

Fig. 6. Pancreatic metastasis. **A** Transverse US scan shows a solid hypoechoic mass at the pancreatic body. **B** Contrast-enhanced US demonstrates that the lesion is mainly hypovascular and necrotic, so that the fine-needle aspiration and biopsy can be guided into the small viable portion of the mass (*arrow*).

can be performed compared to the number with cytological samples.

An integrated radiopathologic service that can evaluate the sampled cytological material means that the correct choice can be made about how to obtain adequate material. As a result, the diagnostic quality is high, and above all, the real-time control of the adequateness of the cytological material considerably reduces the number of cases with nondiagnostic cytology.

Drainage

Before an interventional procedure for the drainage of an inflammatory or postsurgical collection, the patient is studied with conventional US, harmonic US, and Doppler US to select the safest and most effective entry point. For larger collections, the tip of the drainage should always be in the most sloping portion of the lesion (Fig. 5). Local anesthesia is administered in the anterior abdominal wall at the chosen entry point and the selected drainage is positioned with the Trocar technique under US guidance. The guide is then removed only after the tip of the catheter is visualized inside the collection; therefore the progression of the tip is monitored by US for its correct positioning.

Clinical application

Percutaneous diagnostic procedures

Fine-needle aspiration of the pancreas is a simple, cost-effective diagnostic procedure of relatively low risk and high accuracy [7]. The reported accuracies of percutaneous diagnostic pancreatic procedures range from 67% to 97% for US guidance [14, 15] (Table 1) and from 50% to 94% for CT guidance [6, 16] (Table 1). Endoscopic US is highly accurate for small lesions, < 2 cm [17].

The accuracy of percutaneous diagnostic procedures in the literature also varies according to the site of the lesion: a 93%–94% accuracy is reported for lesions in the body-tail of the pancreas [2, 4], slightly higher than what is reported for pancreatic head lesions (83%–84%) [2, 4]. In our series of 135 percutaneous diagnostic procedures performed in 2004, 113 (84%) of the samplings were positive. Of the 22 nondiagnostic samplings, 16 (73%) were on lesions located in the head or the uncinate process and 6 (27%) were in the body or tail. Among the nondiagnostic samplings there were three ductal adenocarcinomas with a diagnosis of chronic pancreatitis at percutaneous sampling. The diagnostic error was explained by an error in guidance, i.e., a region of the lesion was sampled too peripherally, to avoid the necrotic central portions, or the impossibility of reaching the deepest part of the lesion positioned the tip of the needle in the peritumoral inflammatory reaction, with the subsequent collection of material which was obviously inadequate for diagnosis.

Literature reports on complications in percutaneous diagnostic procedures are slightly lower for US guidance than for CT guidance, ranging from 1.7% to 5% for US and from 2.4% to 19% for CT guidance (Table 2).

Percutaneous treatment procedures

Percutaneous drainage under the guidance of imaging is highly efficient in the treatment of pancreatic abscesses, especially in infected pancreatic pseudocysts [4, 6, 8, 10]. The mainly fluid content and the frequent singleness of the lesion explain the great clinical success of the procedure. Percutaneous drainage can be performed under US or CT guidance [17]. The shortest and most direct access route to the pancreas is preferable, avoiding involvement of the neighboring structures. When going through a viscus is unavoidable, the transgastric approach is preferable. The drainage, usually single, can be positioned with the Trocar or,

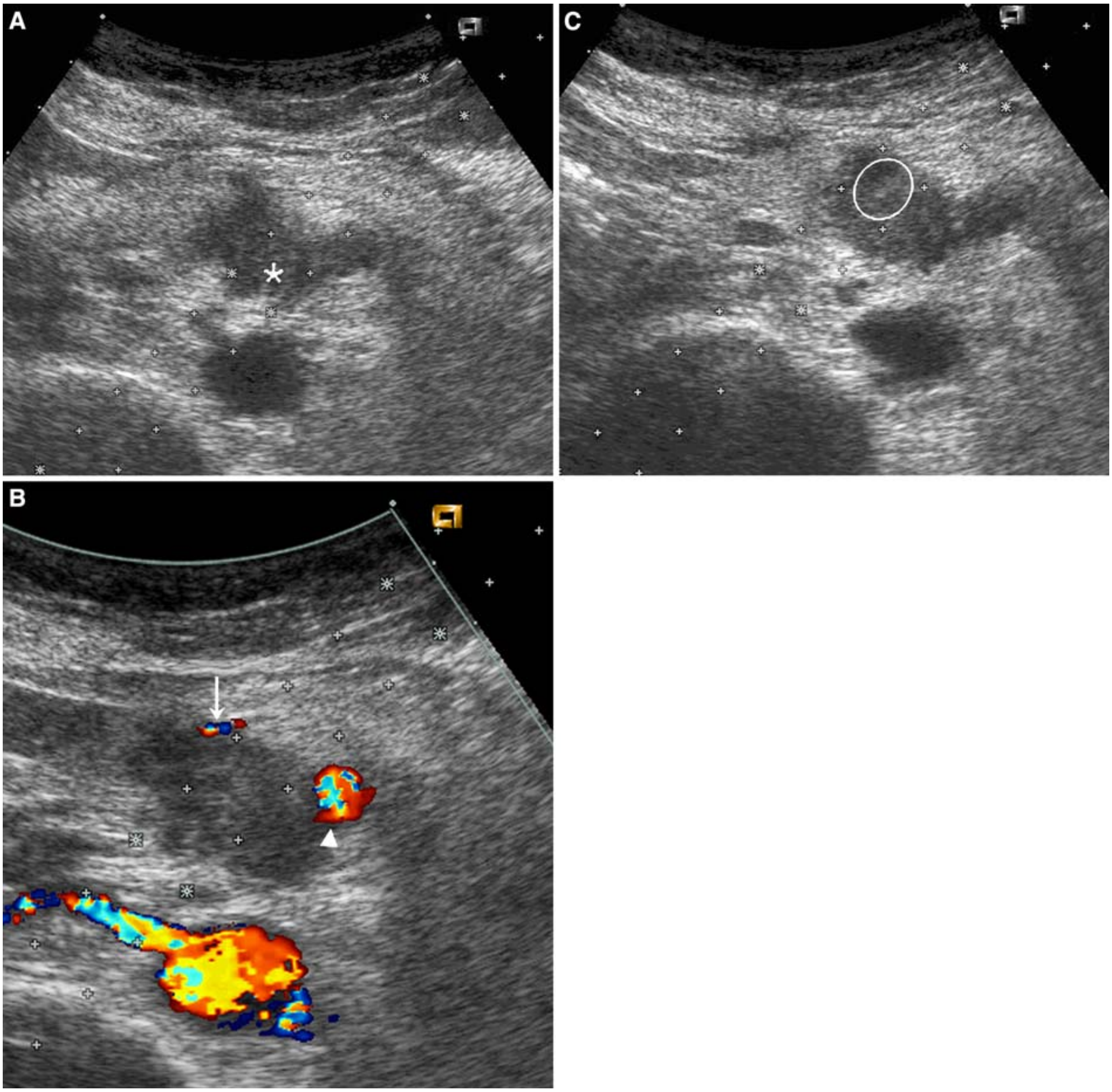

Fig. 7. Fine-needle aspiration of small pancreatic ductal adenocarcinoma. **A** Transverse US scan shows a small hypoechoic mass at the uncinate process of the pancreas (*asterisk*). **B**, **C** At color-Doppler US the mesenteric (*arrowhead*) and gastroduodenal (*arrow*) arteries can be seen better, demonstrating the tumoral infiltration of the mesenteric artery and (**C**) safely guiding the fine-needle aspiration (*circled*).

less often, the Seldinger technique [16]; the latter is preferred for positioning larger catheters. The timing for catheter removal is decided by evaluation of drainage parameters (decrease in output) and imaging features (marked reduction or collapse of the cavity). A sample of the fluid must be obtained during the procedure to assess the presence of amylase, which proves a communication with the main pancreatic duct. The presence and extent of the communication with the main pancreatic duct have important consequences on the percutaneous treatment. While the presence of a slight communication with the secondary ducts only implies the need for more time for the lesion to heal, a communication with the main pancreatic duct obstructed downstream can determine the development of an external pancreatic fistula and/or a relapse in the pancreatic collection. In these cases the surgical approach is compulsory [8].

The results reported in the literature for radiological treatment are extremely variable depending on the type of lesion treated. The fluidity of the infected lesion contents justifies the different success rates reported [18]. Percutaneous drainage of infected pseudocysts has a $>90\%$ clinical success rate, while the results for the

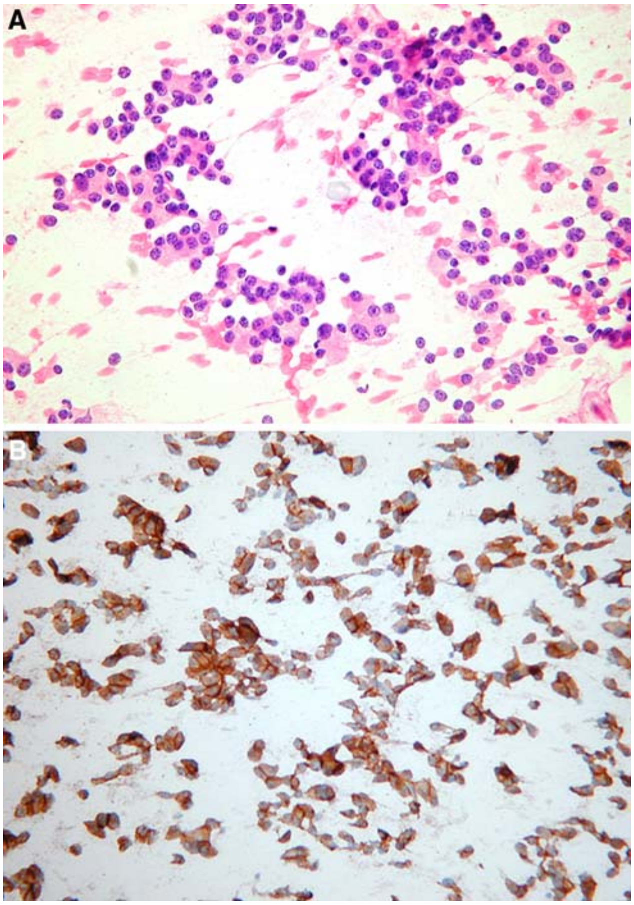

Fig. 8. Fine-needle aspiration of pancreatic neuroendocrine tumor. (**A**) Hematoxylin/eosin and (**B**) immunohistochemical stains of the same cytological sample, with a final diagnosis of neuroendocrine pancreatic tumor.

Table 1. Accuracy of percutaneous diagnostic pancreatic procedure with US and CT guidance: review of the literature

Reference	US guidance	CT guidance
11. Di Stasi et al. (1998)	91%	—
2. Brandt et al. (1993)	95%	86%
10. Sperti et al. (1994)	—	93%
6. Del Maschio et al. (1991)	—	94%
14. Hall-Craggs et al. (1986)	67%	—
15. Bret et al. (1986)	97%	—
16. Fekete et al. (1986)	—	50%

percutaneous treatment of pancreatic abscesses vary from 32% to 90%, and the success rate is $< 50\%$ in infected necrosis (Table 3).

New trends and developments

The administration of contrast media to identify the viable portion of a pancreatic tumor can be considered a useful tool when performing diagnostic interventional percutaneous procedures. Contrast medium administration may increase the accuracy of the diagnostic sampling. Contrast-enhanced US would therefore be recommendable in cases where the sampling was nondiagnostic due to the collection of mainly necrotic material (Fig. 6).

Technical developments have led to image fusion, which is currently available with a navigator (Esaote, Milan, Italy). This type of device in interventional pancreatic procedures would mean that the advantages of US guidance, such as its dynamism and the possibility of innumerable manual scanning planes, would be maintained, and it would also overcome the technical limits of the technique, such as meteorism and obesity, through the simultaneous visualization of the previously acquired CT images, matched and synchronized with the US images (Fig. 9).

Table 2. Complication rate of percutaneous diagnostic pancreatic procedures with US and CT guidance: review of the literature

Reference	US guidance	CT guidance
2. Brandt et al. (1993)	1.7%	3.8%
10. Sperti et al. (1994)	—	2.4%
11. Di Stasi et al. (1998)	5%	—
4. Mallery et al. (2002)	5%	
9. Zech et al. (2002)	—	19%

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Table 3. Outcome of percutaneous drainage for pancreatic infections: review of the literature

Reference	No. pts	Pseudocyst	Abscess	Necrosis	Success
19. Gerzof et al. (1979)	4	2	2	—	75
20. Karlson et al. (1982)	6	—	6	—	50
21. VanSonnenberg et al. (1985)	13	—	13	—	69
22. Steiner et al. (1988)	25	—	25	—	32
23. Freeny et al. (1988)	23	—	23	—	65
24. Stanley et al. (1988)	14	—	16	—	64
25. VanSonnenberg et al. (1989)	48	48	—	—	94
26. Adams et al. (1990)	58		58		79
27. Lee et al. (1992)	30	—	41	—	47
28. Davies et al. (1996)	9	3	5	1	78
29. VanSonnenberg et al. (1997)	59	—	80	—	86
30. Freeny et al. (1998)	34	—	—	34	47

Fig. 9. Fusion imaging-guided fine-needle aspiration of pancreatic ductal adenocarcinoma. The CT image, matched and synchronized with the US image, shows a ductal adenocarcinoma of the pancreatic tail (*asterisk* in CT and US images) not visible at US, so fine-needle aspiration of the lesion dynamically with US guidance can be performed.

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