Percutaneous Biopsy, Aspiration & Drainage

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Preface

Percutaneous radiologic procedures have come of age over recent years. Much of the success of these procedures can be attributed to advances in fluoroscopic and cross-sectional imaging and to advances in instrumentation. In addition, cytologic diagnosis is now readily accepted in many institutions. Aspiration and catheter drainage are also regarded as potentially curative by both radiologists and clinicians. Percutaneous biopsy, aspiration, and drainage represent a significant part of our radiologic practices.

This book is an up-to-date technical guide to percutaneous biopsy, aspiration, and drainage. It discusses localization with fluoroscopy, ultrasound, and computed tomography. It describes biopsy and drainage instrumentation in detail. Regional considerations of biopsy and drainage are made in separate chapters with respect to lesions in the chest, breast, liver, pancreas, kidneys and adrenals, retroperitoneum and pelvis. More detailed analyses of abscess drainage and amniocentesis are included. The accuracy and complications of biopsy and drainage are also discussed.

The goal of this book is to provide a concise, practical guide to biopsy, aspiration, and drainage for the practicing radiologist. A secondary goal is to provide a source of reference for clinicians interested in these procedures.

JANIS G. LETOURNEAU, M.D.

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General Considerations of Percutaneous Biopsy and Drainage

Janis G. Letourneau, M.D.
Morteza K. Elyaderani, M.D.

Fine-needle aspiration biopsy has gained wide acceptance because of its simplicity, safety, and accuracy. In 1930, the pioneers of aspiration biopsy, Martin and Ellis of Memorial Hospital in New York, reported on 65 patients with malignancy confirmed by needle puncture and aspiration.[23] However, the value of the procedure was not appreciated at that time. Newer imaging modalities such as ultrasonography (US) and computed tomography (CT) have contributed to the general popularity of fine-needle aspiration, as they permit more accurate lesion localization. In addition, use of a thin-walled, fine-gauge needle generally assures a safe procedure. With refined techniques and increased experience amongst radiologists and cytologists, the rate of accuracy of fine-needle aspiration biopsy has increased to 80% to 90%, with few complications. Fine-needle aspiration typically yields tissue for cytologic examination, but with technical variations can also yield tissue for histologic examination. Percutaneous biopsy is not limited to the diagnosis of neoplastic processes, as specimens for bacteriologic and chemical analysis may also be sent when appropriate.

The development of percutaneous drainage techniques, both those of simple aspiration and catheter drainage, has paralleled technical advances in aspiration biopsy and other areas of interventional radiology. Similarly, technical developments in US and CT have provided more accurate means of localiza-

tion than was previously available. Therapeutic drainage is frequently performed in conjunction with diagnostic aspiration, although it can be done as a primary procedure.

LOCALIZATION

Precise localization of the mass or fluid collection is essential for performance of a successful biopsy or drainage. This can be accomplished by a variety of means, but most commonly is accomplished by fluoroscopic, sonographic, or CT guidance. Fluoroscopic guidance can be facilitated by administration of contrast in the vascular system (intravenously or intra-arterially), lymphatic system, or biliary system. This chapter will deal with the topics of sonographic and CT localization for percutaneous biopsy and drainage.

Static and real-time sonography can both be used to localize for percutaneous biopsy and drainage. Both linear-array and sector real-time scanners can be used for these purposes. Real-time sonography is better suited for these tasks, as continuous monitoring of the needle position during placement is possible. In many instances, however, continuous visualization of the needle is not necessary, and static images are then sufficient for localization. Biopsy transducers are available for both static and real-time sonographic units.

In general, the target must be localized in two planes. This is best accomplished with the patient in suspended quiet respiration. It is desirable to align the path of the needle so that it is perpendicular to the skin surface, defining the shortest tract for the needle. This is not always possible, however, because of the presence of intervening structures such as the pleural space or the gallbladder. These circumstances may necessitate the use of an angled course. The depth to the target can be determined electronically using the capabilities of the US unit.

Target localization with a static scanner without a biopsy transducer requires repetitive scanning in longitudinal and transverse planes. When a desirable needle course is identified, the transducer is held intermittently in that location and the electronic marking line is activated. The marking line should be exactly superimposed on the intended course of the needle in two planes (Fig 1–1). Before the transducer is removed from the skin, it can be placed precisely over the intended site of needle entry and angled according to the previous localization to provide a final check with the marking line. The transducer is then removed to allow for preparation of the skin at the site of puncture.

Static US units can be used for localization with a biopsy transducer.[15] Such a transducer has a central canal through which a needle can be placed (Fig 1–2). Initial localization is done with a standard transducer as described above. This transducer is then removed and the skin site is prepared for the procedure. The sterilized biopsy transducer is mounted on the articulated arm of the scanner and the target is rescanned using a sterile coupling agent. The intended needle course is again confirmed using the electronic marking line. The distance from the skin to a target point within the mass plus the length of the biopsy transducer is calculated, and this distance is marked on the needle to be used. With this technique the needle tip is not imaged on the screen.

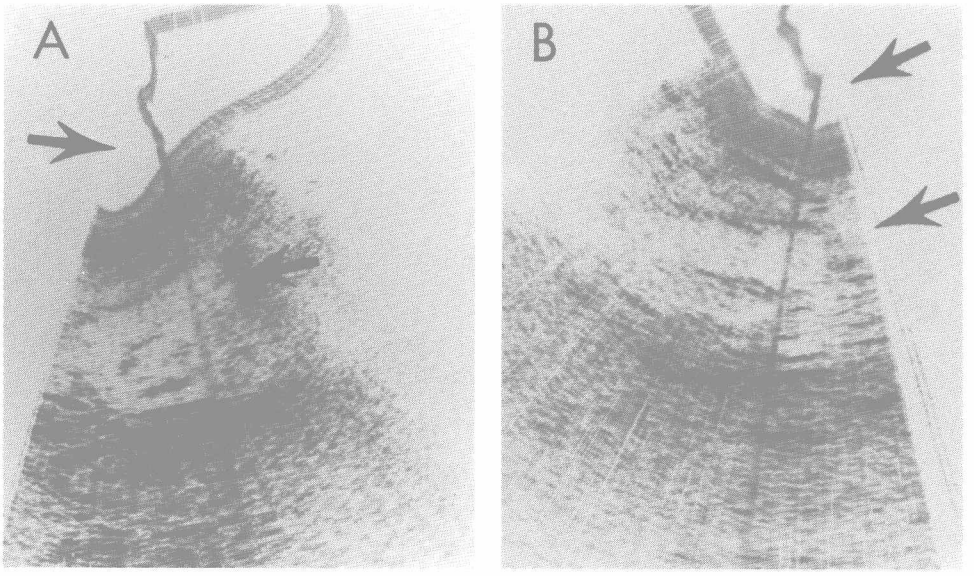

FIG 1–1.
A, transverse and **B,** longitudinal localization of a renal mass *(lower arrows)* by B-mode scanning. Dark line demonstrates the angle of approach *(upper arrows)*.

Once the needle is in position within the target, the biopsy transducer can be removed from the needle through a slit and the remainder of the procedure can be performed without the transducer.

Real-time US units can also be used for localization for percutaneous biopsy or drainage. This can be accomplished without or with a specially de-

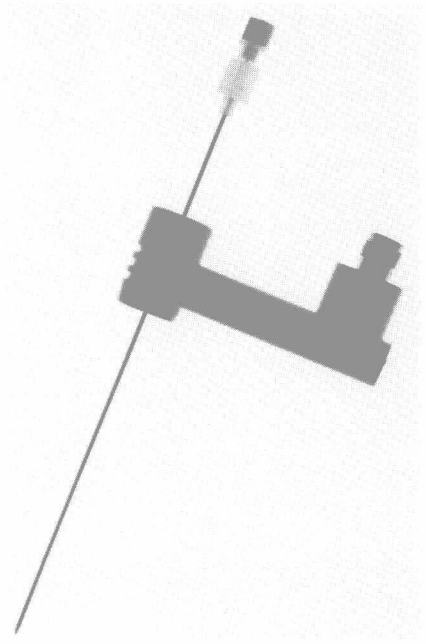

FIG 1–2.
B-mode biopsy transducer with central canal.

signed biopsy transducer or side-arm attachment for the transducer that holds and guides the biopsy needle. Localization of the target in two planes is facilitated with real-time scanning.

Linear-array transducers are constructed from a large number of transducers positioned side-by-side. Their major disadvantage for use in percutaneous procedures is their bulky size, making skin contact sometimes difficult and making manipulations cumbersome. When used without a special biopsy adaptation, a longitudinal scan is made over the region of interest. A 22-gauge needle is then slipped between the transducer and the skin of the patient. The needle casts an acoustic shadow and, by careful repositioning of the needle, the shadow is superimposed on the desired needle tract to the target. This position is then marked on the patient's skin. The procedure is then repeated in the horizontal plane. The intersection of the two needle alignments defines the site of entry of the biopsy needle (Fig 1–3). The depth to the target can be determined electronically from the scanner. The aspirating needle is inserted to the lesion according to the predetermined angle and depth following skin preparation and application of anesthesia. An adaptor for biopsy with linear-array transducers (Fig 1–4) has also been described.[27]

Linear-array biopsy transducers are usually designed with a central canal for needle insertion (Fig 1–5).[26] A small acoustic shadow is produced by the central canal in the center of the image. When this is situated over the target in two planes the needle can be introduced. Other biopsy transducers have a

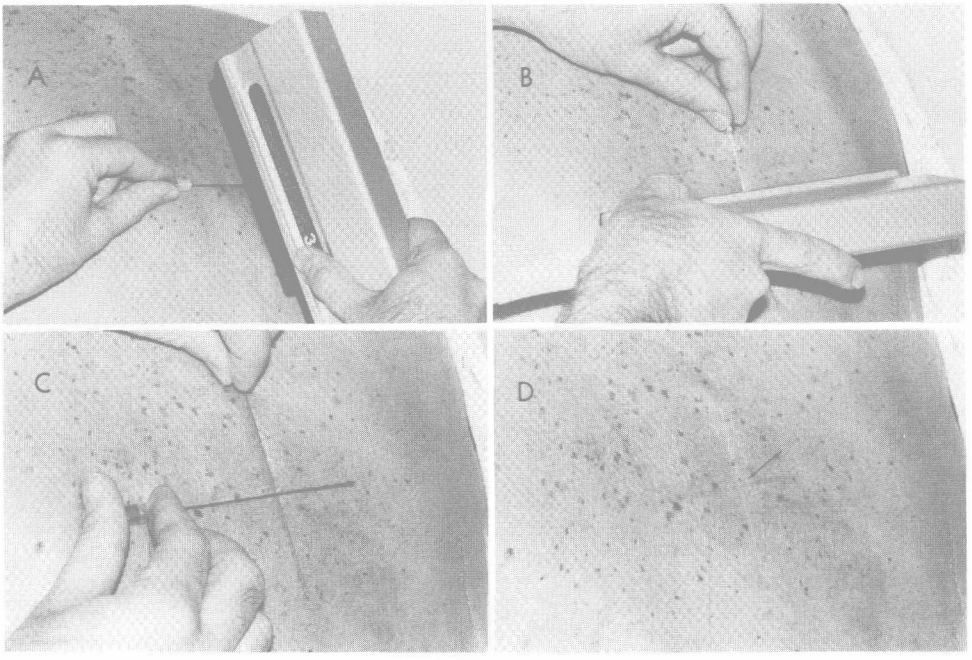

FIG 1–3.
Localization with a linear-array transducer done by slipping a needle between the transducer and the patient's skin. **A,** longitudinal; **B,** transverse; **C,** crossing point of longitudinal and transverse needles; **D,** impression of the needle over the skin *(arrow).*

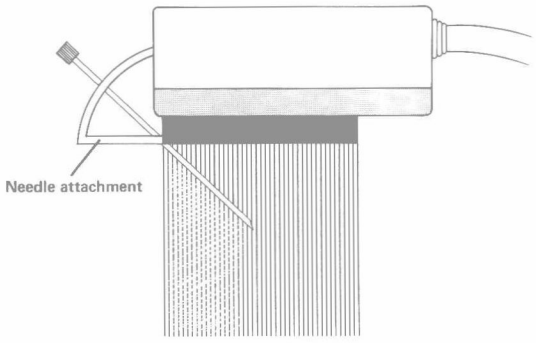

FIG 1–4.
Linear-array biopsy transducer with side attachment for needle insertion.

snap-on attachment on the center of the transducer that holds the aspiration needle in place once the needle tract has been determined. A small canal between the attachment and the transducer allows the needle to be advanced. These transducers must be sterilized before localization and biopsy. A sterile coupling agent is used. The needle is marked to a distance that includes the depth of the target from the skin surface and the height of the biopsy transducer. The needle is advanced in suspended quiet respiration and its position can be monitored. A fine, 22- or 23-gauge needle may not be easily visible, particularly in a solid mass. The position of its tip may be inferred by the presence of an acoustic shadow.[9] Larger needles are more readily visible. When the needle tip is positioned within the target, the transducer can be removed to facilitate aspiration.

Sector scanners can also be used for aspiration procedures. Their compact size permits good skin coupling and facilitates localization and needle manipulation. Side-arm attachments are available for some transducers.[22, 29] These allow advancement of the needle in the sector plane along different degrees of angulation (Fig 1–6). Side-arm attachments must be sterilized for these procedures and are then attached to a sterile or sheathed transducer. An attachment is also available for phased-array real-time scanning units.[5] Their use is not necessary, as the biopsy needle can be advanced alongside the transducer in the plane of the sector. This allows for continuous visualization of the needle shaft and tip during the procedure. In this latter situation, the transducer must

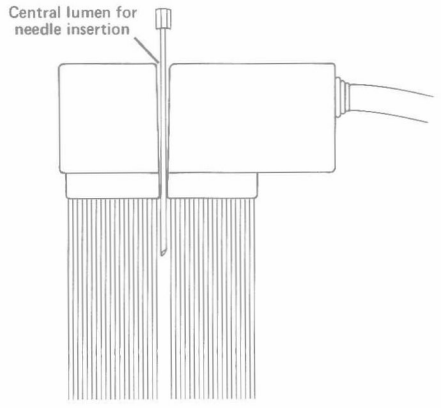

FIG 1–5.
Linear-array biopsy transducer with central canal for needle insertion.

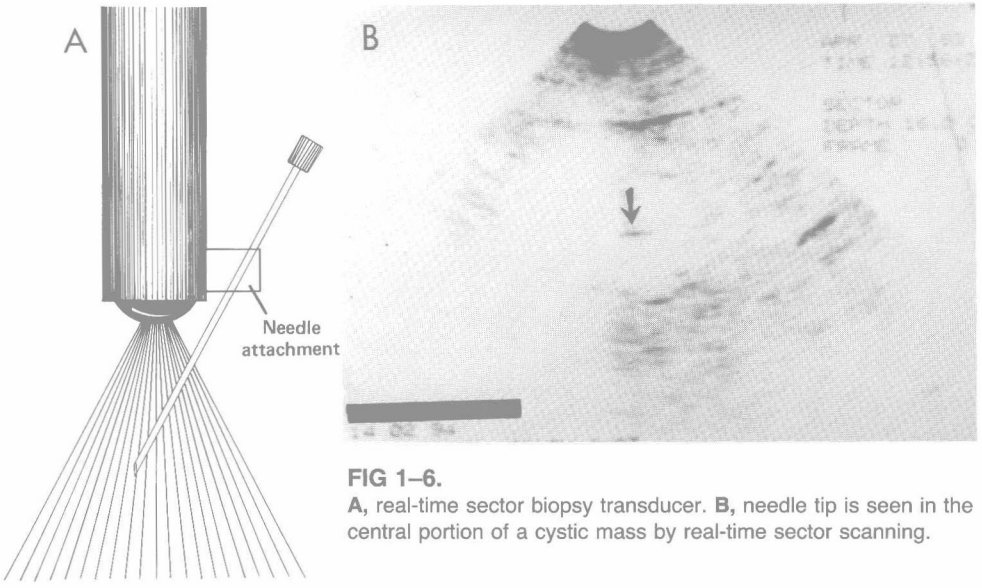

FIG 1–6.
A, real-time sector biopsy transducer. **B,** needle tip is seen in the central portion of a cystic mass by real-time sector scanning.

be sterilized or placed in a sterile glove or sheath coated with an acoustic coupling agent to permit an aseptic procedure.

Localization for percutaneous needle placement with a sector scanner must be done in two perpendicular planes. The target lesion must be situated precisely in the center of the image from these planes of examination. The transducer must also be held at the angle of the intended needle course. This ideally is perpendicular to the skin surface, but this is sometimes not feasible, as mentioned earlier, because of intervening structures.

For all of these methods of localization the patient should be positioned so that the target lesion is most accessible. Planning of intended needle path should also take into account the location of nearby vital structures. When aspiration of freely flowing fluid in the pleural or peritoneal cavities is requested, the patient can be positioned to maximize fluid accumulation in a dependent fashion. Once lesion localization is completed, percutaneous fine-needle biopsy can be performed with a tandem, coaxial, or modified coaxial technique. These techniques are discussed later in this chapter. If the target lesion is superficial in location and distant from vital structures, localization and biopsy can be accomplished with a larger gauge needle.

Computed Tomographic Localization

Computed tomography is also an acceptable means of localization for percutaneous biopsy and drainage. It can be used for localization of lesions in many anatomic regions, including some that are difficult to image by other modalities. It does present some technical limitations. The most compelling of these is one's inability to continuously monitor needle position during placement. More importantly, the needle tip position cannot be confirmed on occasion by repeat scanning, because the location of the lesion, the uninserted length of

the needle, and the small diameter of the gantry aperture do not permit repositioning of the patient in the CT scanner gantry.

Diagnostic images are obtained in a transaxial plane. The patient is then placed in the CT scanner gantry in a position that is thought will make the target lesion most accessible. The optimal plane for biopsy is selected (Fig 1–7,A) and a repeat scan is obtained at that level following placement of a grid or marker on the skin over the region of interest[37] (Fig 1–7,B). This permits a more precise definition of the needle tract, should any angulation of the needle be required to avoid intervening structures. Angulation of the intended needle path from the horizontal or parasagittal planes, as well as the depth to the target lesion, can be determined electronically from the CT scanner.

The intended puncture site is marked and prepared. The needle is inserted with the patient in suspended quiet respiration to the predetermined depth and angle. The patient is allowed to resume quiet respiration and the region is rescanned to verify that the needle tip is in the desired location within the target lesion (Fig 1–7,D). Once this verification is obtained the patient is taken out from the scanner gantry and the procedure is completed.

Depending on the location of lesion and location of nearby potentially vital structures, initial localization may be accomplished with either a fine-needle or

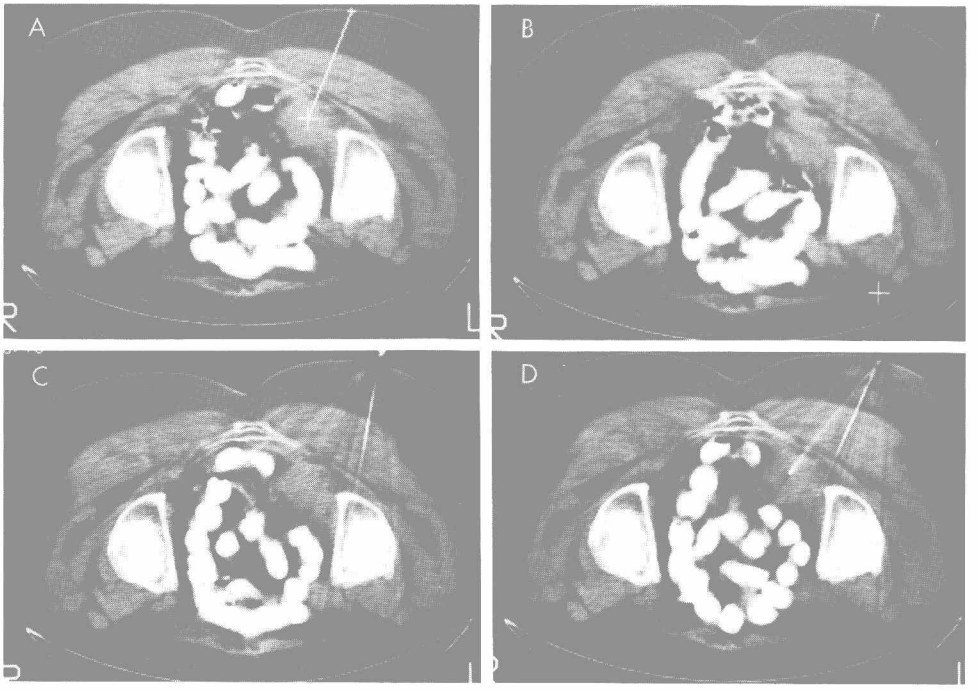

FIG 1–7.

A, computed tomographic image (patient prone) shows a soft-tissue mass in the posterior pelvis. The site of entry and angle of approach are demonstrated. **B,** short 22-gauge needle is inserted at the site of entry and a scan is obtained. **C,** 22-gauge needle is inserted and the scan is repeated. In this figure the needle is not properly directed. **D,** another 22-gauge needle is inserted, with the first needle left in place.

a larger gauge needle. If a fine-needle is chosen for initial localization, biopsy can be performed with a tandem, coaxial, or modified coaxial technique.

As with US localization, it is most desirable to direct the needle course perpendicular to the skin surface. Sometimes, primarily because of location of the pleural reflection, this is not feasible and an angled path must be taken. The angulation of the needle course can be calculated using data relating to the depth of the target lesion and the location of the puncture site (Fig 1–8).[7, 11, 13, 35]

ASPIRATION BIOPSY

Instrumentation

Biopsy Needles

Several kinds of biopsy needles are commercially available, including aspiration, cutting, and screw-type needles. In general, they range in size from 23- to 16-gauge and from 10 to 20 cm in length. It was established long ago in relation to thoracic biopsy that fine-needles are associated with lower incidence of complications[38]; however, the flexibility of thin-walled, fine-caliber needles sometimes makes them difficult to control during placement (Fig 1–9).

The 22- and 23-gauge Chiba needles are frequently used for aspiration biopsy. These have a sharp 25°, beveled tip and inner stylet that prevents tissue from entering the lumen during placement (Fig 1–10). They are primarily used for obtaining cytologic and bacteriologic material, although histologic cores also can be obtained with their use. The Turner needle, available in 16-, 18-, 20-, and 22-gauges, is similar to the Chiba needle, but has a 45° bevel[31] (Fig 1–11). It is thought that the steeper bevel angle makes it easier to obtain a core of tissue for histologic examination.[21]

Many needles have been designed to enhance tissue coring by use of a cutting tip; several of these are also available in fine caliber. The Greene needle

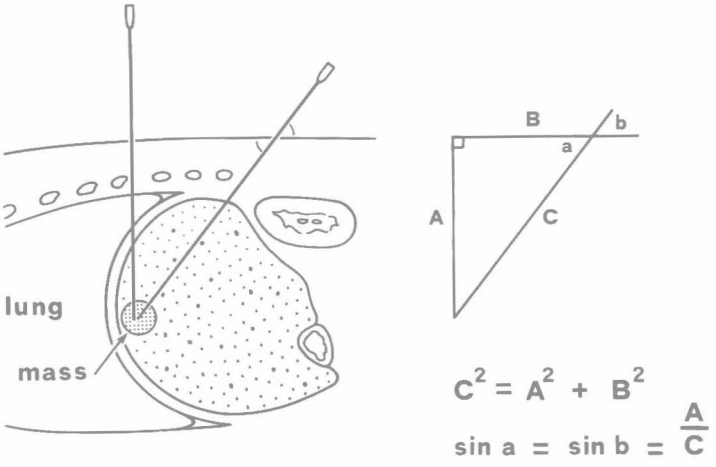

FIG 1–8.
Technique of triangulation fine-needle aspiration by computed tomography.

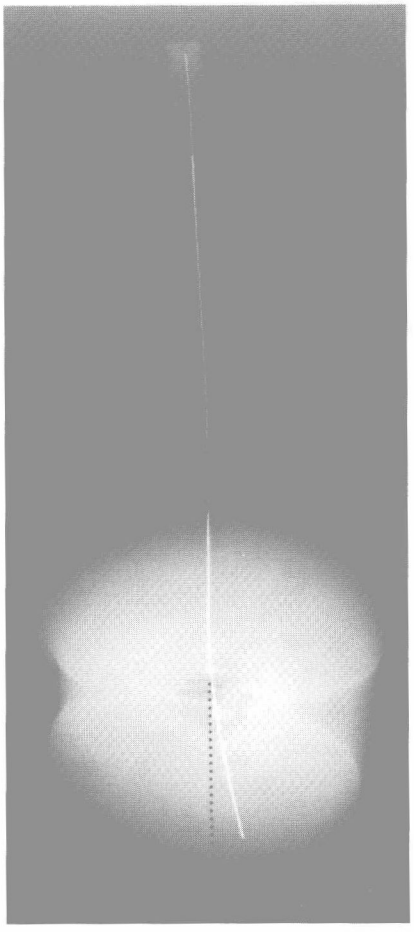

FIG 1–9.
A fine needle bends due to tissue resistance or deep position of target lesion.

is a modified fine-needle (22- and 23-gauge) with a circumferentially sharpened tip that allows the aspiration of a tissue core by means of a rotary movement.[17] The Sure-cut is another cutting needle that is available for aspiration biopsy in 19-, 21- and 22-gauges, as well as in the larger 15-, 16-, 17-, and 18-gauge calibers (Fig 1–12). The Franseen needle, available in 18-, 20-, and 22-gauges, has three cutting serrations that also produce a tissue core or fragments when the needle is rotated[2, 3, 8] (Fig 1–13). The 20-gauge Westcott needle has a slotted tip for obtaining a tissue core[36] (Fig 1–14). The larger 17-gauge Lee needle has a cutting tip and an inner needle fashioned with a biopsy window. It is effective in obtaining histologic specimens.[20] These larger needles, and the even larger 14-gauge Tru-cut needles[12] with a 2-cm long specimen window (Fig 1–15), are recommended for use only when biopsy can be accomplished with the needle coursing through no vital structures or bowel.

Sets for facilitating biopsy with the coaxial technique are also commercially available. These include the Greene biopsy set (Cook, Inc.; Medi-tech, Inc.) with a larger spinal needle for placement and a fine Greene needle for biopsy[10] (Fig 1–16). The vanSonnenberg biopsy set (Cook, Inc.) is also available. It has

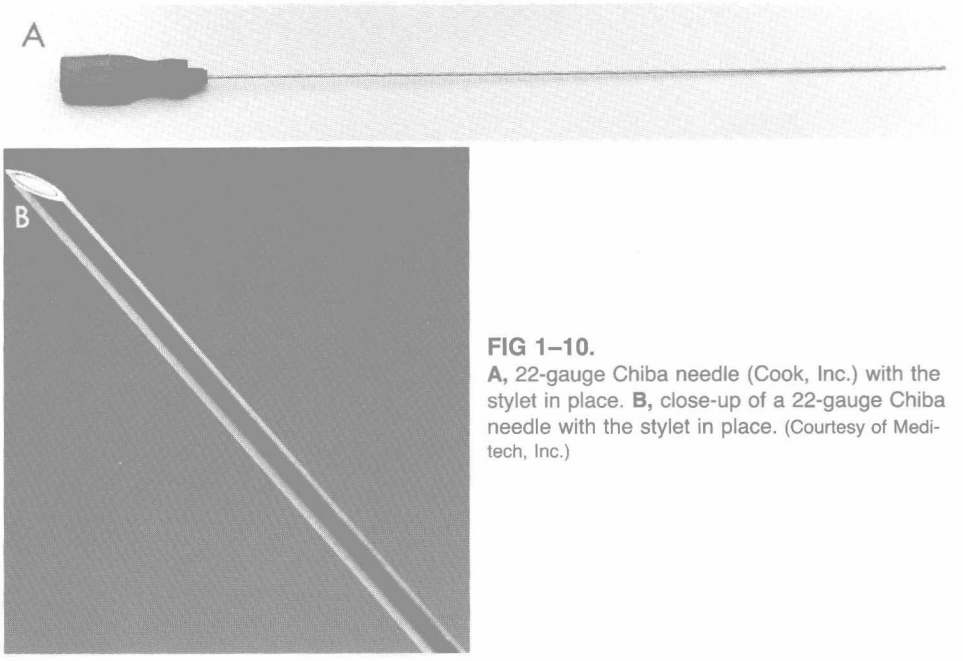

FIG 1–10.
A, 22-gauge Chiba needle (Cook, Inc.) with the stylet in place. **B,** close-up of a 22-gauge Chiba needle with the stylet in place. (Courtesy of Meditech, Inc.)

a fine-needle with a detachable hub for initial placement and a stabilizing larger needle that slides over the needle with a detachable hub. The larger needle provides a guide for repeated fine-needle aspiration biopsy[34] (Fig 1–17).

The Rotex biopsy instrument is a screw-type needle.[25] It consists of a 160-mm long outer cannula that is 1.0 mm in diameter and has a cutting edge at its tip. A screw-tipped stylet, 0.55 mm in diameter and 195 mm in length, is inserted into the outer cannula. Tissue sampling is done with the distal 15 mm of the inner stylet as it is advanced into the lesion. Good diagnostic results have been obtained with this needle in the biopsy of both benign and malignant lesions.[16]

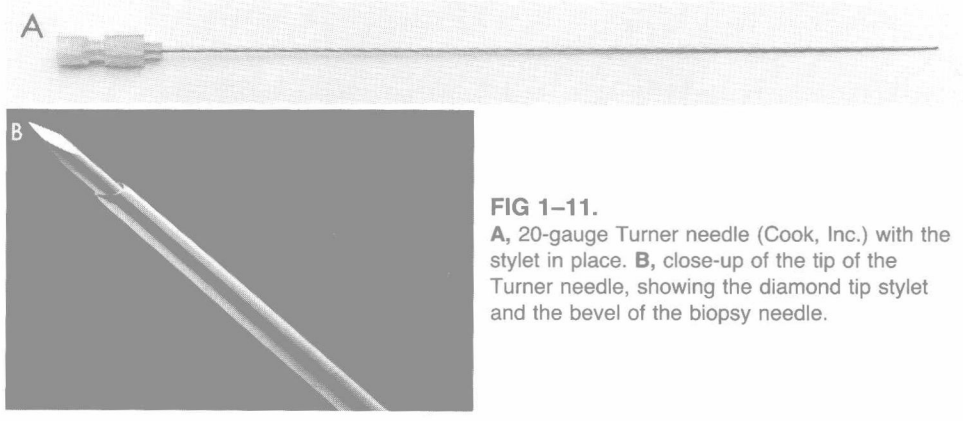

FIG 1–11.
A, 20-gauge Turner needle (Cook, Inc.) with the stylet in place. **B,** close-up of the tip of the Turner needle, showing the diamond tip stylet and the bevel of the biopsy needle.