CT guided biopsy

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Percutaneous biopsy has become a widely used method of obtaining specimens for cytologic, bacteriologic, or pathologic examinations. Its usefulness in the lung,[1,2] genitourinary tract,[2] liver, and bone[2] has been repeatedly documented. Fluoroscopic and ultrasonic guidance have been beneficial in increasing the accuracy in yield of such percutaneous procedures, but there are certain shortcomings with both. The purpose of this paper is to (1) explain the imaging properties of computed tomography (CT) scanning which make it a useful tool for guiding percutaneous procedures; (2) describe techniques and instruments which can be utilized by this means; (3) discuss the indications for utilizing CT guided procedures compared to other conventional guidance means; and (4) review in each organ system the abnormalities we believe are suited to CT percutaneous procedure.

Advantages of CT guidance

The first distinct advantage of the CT method is the remarkable quality of the image provided by the scanner for detecting the pathology and guiding the instruments. The image is a complete anatomic cross section of all structures within the transverse slice including the solid parenchymal organs, major blood vessels, gas-filled intestine, and adjacent bony structures. Such a cross section "lays out" the anatomy without the superimposition of densities which can occur when using fluoroscopy or plain film. Because the CT scanner employs an x-ray beam which can penetrate both gas and bone, these two extremes of density can be displayed without such interference as occurs with ultrasound. Besides imaging extremes of density, the scanner can discriminate 2% density changes so that cystic collections of fluid or small pockets of gas can be clearly seen on the scan even though they are not visible by conventional roentgenography.

Perhaps the most important attribute of CT guidance is the high degree of accuracy in placing instruments into specific abnormalities. To assess the accuracy of instrument placement, a schematic drawing of the body in relationship to an X-Y-Z axis may be used (*Fig. 1*). If a scan is obtained which images the needle, then localization within the Z-axis has occurred since the needle would not be seen if it were not within the 13-mm slice of the CT scan. The needle must therefore lie within +6 mm or −6 mm in the Z axis. Localization in the X-Y axis is even more accurate; the resolution of the scanners in this plane are in the region of 3 mm.

CT procedures also afford versatility of method. A variety of instruments may be selected depending upon the abnormality and the clinical situation of the patient. We have used instruments ranging from a 23-gauge spinal needle to a 14-gauge Menghini needle. With these different instruments one can choose simply to obtain a cytologic aspiration specimen with the very small gauge needle or a core biopsy with the Menghini needle. Because the patient is examined with an air interface, and because the anatomic display is so accurate, a variety of clinical situations can be approached with this method, which would be difficult by other means. Since the scanner uses an air interface and does not need a coupling medium such as oil, patients with draining fistulae, sinuses, ileostomies, or external drainage devices can still be examined and biopsies can be performed. If there is a clinical problem, e.g., a pancreatic neoplasm which is producing severe back pain and the patient is unable to lie on his back for a percutaneous aspiration procedure, the examination and biopsy can be performed with the patient lying on the right side (*Fig. 2A*).

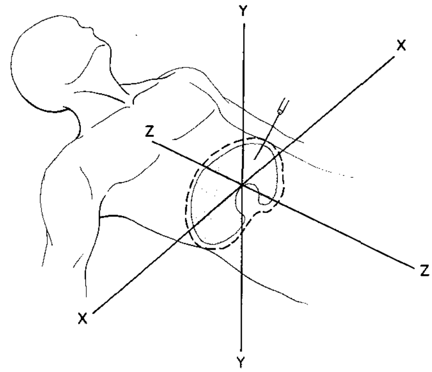

Fig. 1. Schematic drawing of the body in relationship to the X-Y-Z axis. The cross section image corresponds to the 13-mm anatomic slice displayed by the CT scan.

Techniques

There are two basic techniques, double needle and single needle, involved with CT guided biopsies. The double needle technique employs an

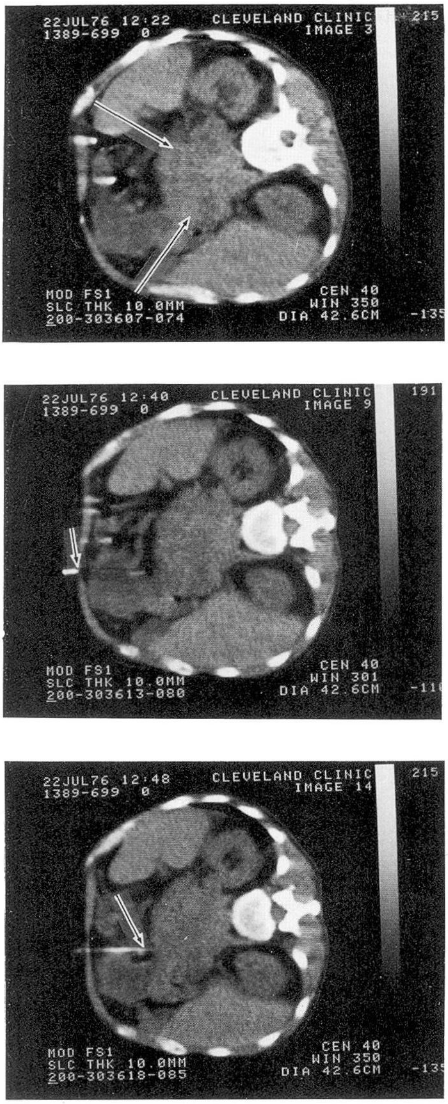

Fig. 2. A, This patient with a pancreatic mass (arrows) could not be examined on his back because of severe pain. The patient was positioned on his right side and was able to tolerate both the examination and a biopsy procedure. **B,** Repeat scan of the same patient following placement of the 18-gauge disposable needle (arrow) into the abdominal cavity surface. Arrow indicates the needle in place within the abdomen. **C,** The fine gauge spinal needle (arrow) has been inserted into the pancreatic mass for the aspiration specimen. Arrow points to the tip of the needle located within the mass.

outer cannula which directs the longer aspiration needle toward the abnormality. The single needle technique does not employ such an outer guidance cannula and is typically used with larger needles such as an 18-gauge spinal needle or a 14-gauge Menghini needle.

Double needle technique. After a series of diagnostic scans and after the abnormality has been located, the entry point is selected. A metal marker is taped onto that point of the skin surface tentatively selected, at which time a repeat scan is performed. The metal marker can be noted on the scan and if this point appears close to the abnormality the procedure is continued. After povidone-iodine (Betadine) preparation, and a local anesthetic is given, a disposable 18-gauge needle is inserted into the cavity surface and a rescan is taken (*Fig. 2B*). If the needle, which appears as a light line on the scan, is directed toward the abnormality and the tentative path appears suitable, the fine gauge spinal needle is inserted (*Fig. 2C*). After the depth of the lesion is measured from the scan, the patient is asked to hold his breath and the needle is inserted to the depth of the lesion. A scan is then repeated to localize the needle point in relationship to the lesion. If it is exactly placed, an aspiration specimen is obtained.

Single needle technique. The single needle technique is even less complicated. In this procedure, after the entry point is selected and the patient is prepared, the instrument is introduced into the cavity surface and a scan obtained. If the needle is directed correctly toward the abnormality, it is inserted to the measured depth. A rescan is taken immediately before the sampling, and if the point is properly placed a specimen is obtained.

The first method is the more accurate and safer of the two. In the first method the guidance needle is directed toward the abnormality before the sampling needle is introduced. Also, a fine gauge needle is safer than a needle with a larger gauge. Of course, the specimens obtained by this first method are small and useful only for bacteriologic or cytologic diagnosis; with the second method, a large core biopsy specimen is obtained which can be used either for a frozen section or pathologic study. There have been no significant complications with either technique.

Indications

The indications for the CT guidance procedure are either primary or secondary. In the primary role, there are no other suitable imaging techniques which can accurately guide the percutaneous procedures, or there is an exceptional clinical situation in which the advantages of the CT guidance are indicated. In the secondary role, the CT scanner is utilized as a backup system to perform biopsies when other guidance modalities have been unsuccessful. In view of the broad utilization and potential of the CT scanner, it appears that this secondary role will perhaps be more important in the near future.

CT application in different organ systems

Lung. CT scanning of the lung is advantageous for displaying pleural lesions and lesions within the costal vertebral angles. Because of the excellent visualization of these areas, accurate needle placement is possible. This represents a secondary area for CT guidance. We believe that fluoroscopy should be used first to aspirate any lesion in the lung.

Liver. Percutaneous procedures of the liver have been useful for application of the methods described. When isolated lesions within the liver are shown either on the isotope scan or on a previous Delta scan, then a CT guided procedure is indicated to obtain a specimen from this localized area. If the disease is diffuse and many areas are involved, a blind percutaneous procedure of the liver is indicated prior to the CT guided procedure. In our experience we have successfully aspirated or performed biopsies on abscesses, cysts and neoplasms, both primary and secondary. In our early experience, aspiration procedures were performed for all abnormalities, but these did not yield adequate tissue from neoplasms for good pathologic evaluations; we presently use an 18-gauge Menghini needle to obtain a core biopsy of tumors within the liver (*Fig. 3*).

The obvious advantages of this technique are that one is better able to avoid other structures such as the

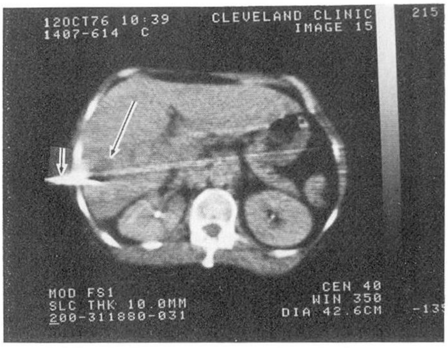

Fig. 3. A metastatic lesion (long arrow) shown within the liver appeared as an area of decreased attenuation (darker area). A Menghini needle (short arrow) was introduced into the area and a biopsy specimen obtained.

diaphragm, costophrenic angles, colon, and gallbladder, and there is a higher probability of obtaining a positive specimen. Complications from postbiopsy bleeding should be no different from that of the blind technique.

Biliary system. CT guided procedures of the biliary system have included both diagnostic cholangiograms and therapeutic drainage procedures to relieve obstructive jaundice. We do not believe that diagnostic cholangiograms should be performed under CT guidance, because of the previously demonstrated efficacy of fluoroscopic guided fine needle cholangiography. However, on three occasions jaundice developed in terminally ill patients and we were successful in relieving the jaundice by percutaneous drainage. In these patients we were able to place a needle into the main biliary radicle and, using a Seldinger technique, put a catheter in the biliary system which provided drainage and relief from the obstructive jaundice (*Fig. 4*).

Pancreas. Fine needle aspirations of the pancreas for confirmation of neoplasm have been performed on numerous occasions (*Fig. 2B and C*).

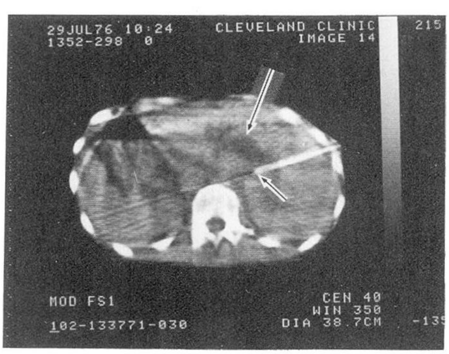

Fig. 4. A needle puncture (short arrow) of the main biliary radicle (long arrow) was performed to enable placement of a catheter for temporary biliary drainage.

Fig. 5. The scan demonstrates a mass lesion (arrow) of the kidney of intermediate density. It could represent a high density cyst or a low density carcinoma. Aspiration of the mass was indicated because of the intermediate density. This demonstrates needle placement into the mass which later proved to be a cyst.

With this method the double needle technique is used, but is suitable for obtaining material only for cytologic examination. The specific technique has been discussed previously[3] and will not be reviewed in detail. To date no pancreatic fistulae have been reported with this technique or with an ultrasonic guided technique in which a similar type of needle is used.

The exact role of this procedure for patients with neoplastic disease is not clear at this time; certain patients who have extensive disease not confirmed histologically may be candidates for this procedure.

Genitourinary tract. Percutaneous punctures of the genitourinary tract have been done frequently for cysts, neoplasms, antegrade pyelography, and percutaneous nephrostomies.[4]

Mass lesions of the kidney which appear somewhat high in density and yet do not have the characteristics of neoplasms are those we believe should be punctured (*Fig. 5*). For renal cysts of significant size fluoroscopy should be attempted, and if this technique is unsuccessful, then a CT guided procedure is indicated. Biopsy of the neoplasm is not indicated, except in those cases the clinician considers inoperable and a histologic diagnosis is desired for either chemotherapy or radiation therapy.

Puncture of the renal pelvis for either antegrade pyelography or percutaneous nephrostomies are also easily accomplished with the CT scanner (*Fig. 6*). The scanner is capable of imaging the renal pelvis with or without contrast material and provides an excellent cross section that permits accurate placement of the needle. Fluoroscopy should be done in patients with severely dilated renal pelves that contain sufficient contrast material visible by fluoroscopy; if fluoroscopy is unsuccessful, CT is indicated.

Retroperitoneum. The retroperitoneum contains a large amount of fat that is easily imaged with the CT scan. With the excellent image provided of lesions and surrounding anatomy, it is possible to perform a biopsy. However, not every retroperitoneal lesion lends itself to CT guidance (*Fig. 7*). The location and characteristics of the individual neoplasm indicate whether the biopsy should be attempted. Individual considera-

Fig. 6. Dilated pelves on both the right and left sides; the scan demonstrates needle placement (arrows) into both renal pelves.

Fig. 7. A large retroperitoneal mass displaces the calcified aorta (short arrow) anteriorly from the vertebral body. A needle biopsy (long arrow) specimen yielded atypical lymphatic cells, possibly malignant lymphoma.

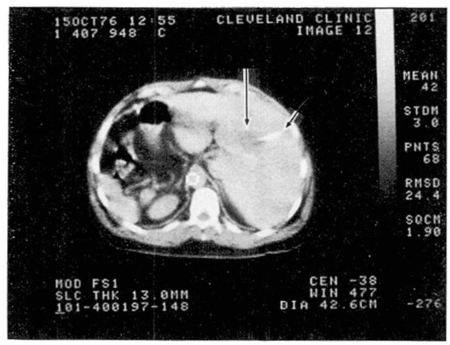

Fig. 8. This suspected abscess (long arrow) appears as an area of decreased attenuation similar in density to water. The metal needle (short arrow) is located within the cyst cavity; the contents were aspirated for cytologic and bacteriologic diagnosis.

tion should be made before deciding to perform such a biopsy.

Abscesses. Intraabdominal abscesses can be accurately imaged[5] and punctured with the CT guided procedure; either a specimen can be obtained or a drainage procedure performed (*Fig. 8*). If merely a specimen for culture is desired, the double needle fine gauge technique is recommended because of its great accuracy and safety. If the purulent material is thick, it may be necessary to use a Teflon sheath splenoportogram needle to obtain the material. On one occasion we drained a large intrahepatic abscess primarily by percutaneous trocar and a Foley balloon catheter; this method is now being evaluated in inoperable patients.

Aspiration or drainage of such abscess cavities needs to be carefully considered with all the clinical data available. There should be a close consultation with the specialists in infectious diseases for determining the need for systemic antibiotic therapy either before or immediately after the procedure.

Conclusion

CT guided percutaneous procedures are the most accurate means of performing any percutaneous biopsy. These procedures have been useful in the many different organ systems discussed. However, because of the broad utilization of the scanning device for many investigations, we believe that CT guided procedures should be limited to those areas previously indicated. It is hoped that this new guidance system will be capable of expediting the diagnosis and treatment by obtaining specific specimens. As a result, the mortality and morbidity of some of these disorders may be decreased. Although the method appears extremely promising, further investigation of specific applications is required to find its proper role.

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