Computerized tomography guided percutaneous procedures

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Abstract

The main indications for computerized tomography (CT) guided percutaneous procedures are reviewed and some of the techniques involved are described.

The authors also analyze the main applications of CT guided diagnostic and therapeutic procedures of specific organs and sites, some of which are illustrated with iconography from our hospital. The diagnostic sensitivity and specificity are looked at, as well as the therapeutic outcome of this approach.

Key words: computerized tomography, international radiology, guided biopsies.

Introduction

During the last two decades, imaging-guided percutaneous puncture has seen substantial development, and it is currently used as a first-line intervention method for both diagnostic and therapeutic applications.

Radioscopy, ultrasound and computed tomography (CT) are the main techniques used to guide the introduction and placement of material.[1]

CT provides significant morphological detail resulting from high spatial resolution and contrast, enabling the visualization of the lungs and the digestive tract (with air inside), the visceral mass, blood vessels and bone, as well as contrast media administered orally, rectally, or intravenously. Because it enables the precise localization of the tip of the puncture needle, this method is ideal for guiding the puncture of lesions with millimeter accuracy, and is the safest in preventing complications.

By associating low morbidity and mortality with a high diagnostic yield, particularly when the material collected is subjected to immediate analysis, onsite, by the pathologist, in order to determine the quantity and the quality of the sample, percutaneous puncture guided by CT represents a significant advance in terms of time savings, reducing the period required to obtain a definitive diagnosis, and even reducing hospitalization times. The savings of resources, eliminating the need for additional or repeated diagnostic exams, is another attraction of this type of procedure.

On the therapeutic side, CT-guided percutaneous puncture enables the drainage of fluids that was previously only possible through surgery, enabling a faster recovery, reducing hospitalization times and easing the burden on surgery units.

Despite the enormous potential of this type of procedure, its complete success is directly dependent upon the work of a multidisciplinary team, led by the clinician, the anatomopathologist and the imaging technician. In this field, in addition to executing the procedure, the imaging technician must also thoroughly evaluate the clinician's requests, to avoid the danger of trivializing CT-guided punctures, which always carry a risk. It is also the clinician's responsibility to recommend other diagnostic procedures (radioscopy, ultrasound) when these are more appropriate for a given situation.

Indications for percutaneous puncture are constantly changing as new equipment is developed, experience is accumulated, and the risks and benefits of the technique are further defined.[2]

General indications

The most common clinical indications for guided puncture include:[1,2,3] swollen lymph nodes or tumors of lymphatic origin, either undiagnosed or under pre- or post-treatment evaluation; obtaining a sample of

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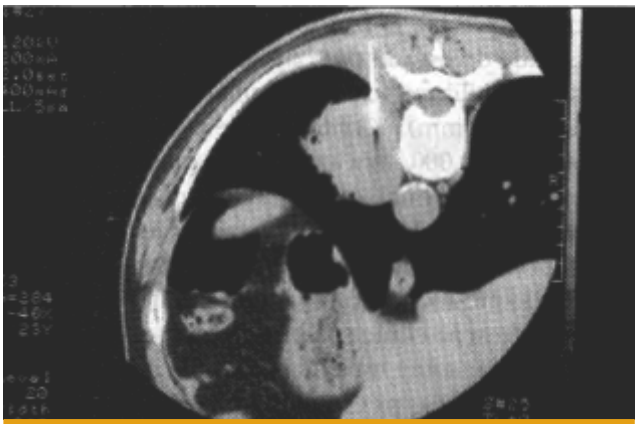


Small-cell lung carcinoma (aspiration needle).

FIG. 1

Liver metastasis of carcinoid of the ileum (modified aspiration needle).

FIG. 2

the tumor to determine its therapeutic sensitivity, cell typing or hormone dependency; suspected metastasis of unknown origin or in patients with primary malignancies; suspected metastasis in patients with malignancies in clinical remission; persistence of a tumor following radiation or chemotherapy; differential diagnosis between local recurrence of a tumor, and scar tissue, or between a tumor and an inflammatory mass; tumors of unknown histology and with no surgical indication; repeat diagnostic puncture when other methods have been unsuccessful; cytological or bacteriological diagnosis; neurolysis; and placement of radiotherapeutic implants.

There are other situations where CT is indicated as the preferred method for guiding puncture, including lesions not easily revealed via other imaging techniques, masses with a diameter of less than 3 cm, lesions close to the bone, blood vessels or other important structures and deep lesions or mediastinal masses.[2]

Diagnostic CT-guided percutaneous punctures

Diagnostic percutaneous punctures are the most frequently used CT-guided procedures.

By providing a pathological anatomy diagnosis, diagnostic puncture can eliminate the need for surgery guiding a palliative treatment in a patient with an incurable malignancy. In other cases, it enables the formulation of a more accurate pre-treatment plan.

Whenever possible, a complete tomodensitometry study, for diagnostic purposes only, should be obtained, preferably not at the same time as the puncture is carried out.[2] In this way a discussion can be conducted relating to the indication, the approach, preliminary care and the material to be selected.

Both diagnostic and therapeutic punctures currently require the following preparations: fasting of the patient to eliminate the risk of aspiration in the event of vomiting, informed consent preferably signed by the patient, a study of renal function (by the administration of an intravenous contrast agent if needed) and a coagulation study (prothrombin time and platelet count). Most authors defend a coagulation study only when a needle with a caliber larger than 20 G (0.89 mm) is to be used. Platelet counts lower than 50,000-100,000/mm^3 and prothrombin times 50% above the normal values (in seconds) are only contraindications when it comes to performing the procedure, and can generally be corrected prior to the procedure. When puncture is indicated and yet bleeding diathesis persists, a smaller caliber needle should be chosen and preparations should be made for a possible blood transfusion.[2]

Some post-puncture care indications will be addressed in the chapters corresponding to each organ or specific region.

Types of needles1

There is a wide variety of needles available for performing diagnostic percutaneous punctures. The choice of needle caliber and type of tip depend on

Adenocarcinoma of the tail of the pancreas – anterior transintestinal puncture (aspiration needle).

FIG. 3

Adrenal tuberculosis – posterior puncture and aspiration of abscess (aspiration needle).

FIG. 4

the type and location of the lesion to be biopsied, the type of sample required for pathological anatomy diagnosis, the structures adjacent to the lesion, and largely, on the individual preference of the radiologist and pathologist.

Three types of needles are available: aspiration needles, modified aspiration needles and biopsy needles.

Aspiration needles have a beveled tip and a caliber of between 20 and 22 G. This type of needle allows suitable material to be obtained for cytology, and is particularly useful when other organs, especially intestinal loops, need to be passed through to get at the sample area. Punctures of intestinal structures or blood vessels with a 22G-caliber needle is safe, and often unavoidable in cases of deep lesions. The major drawback of this type of needle is that due to its great flexibility, it is difficult to target to the area of interest in obese patients. Additionally, the type of sample obtained requires the availability of a cytopathologist, which is not always possible. Modified aspiration needles combine the safety of a "fine" needle with the possibility of obtaining enough tissue for histological analysis. They are available in calibers of between 18 and 22 G, and with a wide variety of tip configurations, which are selected according to the organ or region to be punctured.

Biopsy needles, available in calibers of between 14 an 20 G, enable excellent histological analysis by allowing small tissue fragments to be obtained using a guillotine mechanism. Due to the increased risk of bleeding, this needle is generally only used in hospitalized patients.

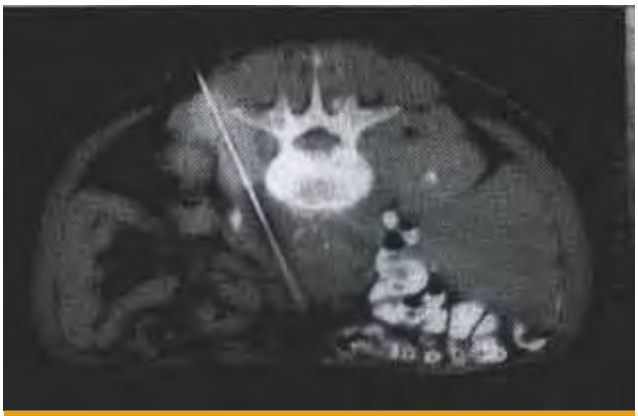
In each of the chapters on different organs or regions, reference will be made to the general criteria for needle choice in each particular case.

Technique

The analysis of a tomodensitometry diagnostic exam allows the technician to establish the best positioning of the patient (decubitus, dorsal, ventral or lateral), as well as to determine the level at which the lesion is found, in order to obtain axial slices of the region of interest. Once the appropriate depth for puncture and the point of entry for the needle are selected, the distance from this point to both midline and the lesion are determined. Next, a metallic marker is placed on the skin at the site of needle entry. The axial slice then obtained confirms the ideal site for needle entry. Ideally, the shortest vertical path between the skin and the lesion should be chosen, although sometimes a longer or more angular trajectory is opted for, to avoid important structures or in the case of certain liver lesions.

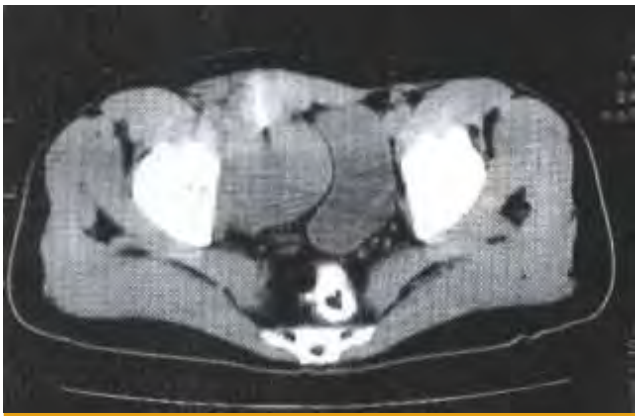
In order to avoid areas of necrosis that exist in some lesions, the use of an intravenous contrast agent may be advisable to determine viable areas.

Following the appropriate local aseptic and anesthetic procedures, the needle is inserted along the determined path, to the desired depth, to obtain - provided the site of the lesion to be punctured and the caliber of the needle permit - an axial slice to guide the needle into the interior of the lesion.



Non-Hodgkin lymphoma – Lumbar-aortic swollen lymph nodes. Posterior approach (biopsy needle).

FIG. 5



Hodgkin's lymphoma – pelvic swollen lymph nodes. Anterior approach (biopsy needle).

FIG. 6

The material is subsequently collected using a technique suitable for the type of needle being used.

Complications

Vast experience using "fine" needles has shown that the inadvertent puncture of vascular structures, even large blood vessels, the stomach or intestinal loops, the bladder, the urethra or the gall bladder are not generally associated with complications resulting in clinical symptoms.[1]

Theoretically, the risk of complications increases in direct relationship to the caliber of the needle, especially in the case of needles with the guillotine mechanism. Even so, the risk remains minimal in these cases, provided the appropriate precautions are taken and CT guidance is used.[1]

The overall complication rate is approximately 2%.[1] The most common complications are vagal reaction and transitory fever. Bleeding is the most frequently occurring complication of clinical significance, though only 1% is serious enough to require a blood transfusion. Other complications, such as bacterial contamination or sepsis, are rare, occurring at a percentage of less than 1%. Neoplastic dissemination along the trajectory of the needle is described in 0.003 to 0.009% of cases.[2] The mortality rate varies between 0.006 and 0.1%.[2]

No technique is completely effective in preventing complications, and patients should be closely monitored for 2 to 3 hours following the procedure. When performed as an outpatient procedure, the patient should be instructed to seek emergency treatment in the event of persistent or increasing pain, high fever, or signs of bleeding.

Puncture of organs or specific locations

Thorax

The use of CT is preferred when the lesions are small and barely visible by x-ray, or when they occur close to important vascular structures and in many of the mediastinal locations.[2] Main indications include the suspicion of bronchial carcinoma in a solitary pulmonary nodule, an inoperable lung tumor, the suspicion of pulmonary metastasis, a lung tumor that is suspected to be the source of known metastases, an infiltrative or nodular pulmonary lesion in an immunocompromised patient, a lesion suspected to be of infectious origin, interstitial syndromes with alveolitis, mediastinal tumor lesions and lesions of the pleura and chest wall,[3] when clinical and other complementary diagnostic exams do not give total clarification. Contraindications related to the execution of the procedure include chronic obstructive pulmonary disease, severe respiratory failure, severe pulmonary hypertension, a single lung and cough.[3]

As a rule, small-caliber aspiration needles are used, although larger-caliber or even biopsy needles may be used when there is no interposition of the lung in the trajectory of the needle.

Pneumothorax is the major complication associated with thoracic puncture, occurring in 10 to 15%

Sacroiliitis. Posterior approach (aspiration needle)

FIG. 7

Aspiration of septate pleural pericardial empyema (aspiration needle).

FIG. 8

of cases. However, thoracic drainage is required in only 10 to 20% of these cases.[1] For this reason, the patient should be given a chest x-ray within about an hour after the puncture. If a small pneumothorax is detected, the patient should be monitored for the next 3 or 4 hours, after which the exam should be repeated. If the pneumothorax has not grown in size, the patient is authorized to go home. Other possible complications include haemoptysis and air embolism.

The sensitivity of the pulmonary puncture method varies between 90 and 100%, with specificity close to 99%.[3] False positives are rare, with false negatives occurring more frequently. This fact depends upon the number of samples taken, the experience of the technician, the size of the lesion and the existence of tumor necrosis. In mediastinal punctures, sensitivity ranges from 85 to 95%, with the exception of cases of lymphoma or thymoma where it ranges from 65 to 85%.[3] Punctures of the pleura and chest walls yield results similar to pulmonary punctures, except in cases of mesothelioma where the diagnosis is sometimes difficult.[3]

Liver

Although a "blind" liver biopsy is the method indicated when diffuse liver disease is suspected, with a diagnostic accuracy ranging from 80 to 100%, in cases of focal lesions, this percentage drops significantly to between 20 and 60%.[1] Liver lesion punctures guided by ultrasound or CT, however, have achieved a diagnostic accuracy of 85 to 95%.[1] CT guidance is only recommended when the lesion is not visible via ultrasound due to size, depth, proximity to the diaphragm, to attributes of the ultrasound, or to the overlapping position of the ribs.[1]

The main indications[3,4] of this approach include suspicion of a secondary lesion of the liver or hepatocellular carcinoma without surgical indication, when clinical and other complementary diagnostic exams and bacteriological studies of infected lesions are inconclusive.

The puncture of hydatid cysts, haemangiomas, adenomas, and the liver in the presence of ascites, is contraindicated.

When the metastatic lesion of a known cancer is suspected and it is necessary for the needle to follow a long trajectory, or if the lesions are small in size, needles of the aspiration type are preferred. If occult metastatic neoplasia or metastasis of the primary lesion is suspected, a biopsy needle is used.

Complications of clinical significance arising from liver puncture are rare (approximately 1%), bleeding being the most frequent. Other possible complications include biliary peritonitis, pneumothorax, carcinoid crisis[2] in cases of the puncture of metastases of this tumor, false aneurisms and arteriovenous fistulas.

Diagnostic sensitivity ranges from 83 to 93% with biopsy needles, and is around 66% when aspiration needles are used.[3] Specificity is close to 100% for both for cytology and histology.[3]

Pancreas

The most common indication for puncture of the pancreas is a differential diagnosis between pancreatic neoplasia and chronic pancreatitis, when the gland presents either diffuse or localized enlargement.[2,4] This distinction is sometimes difficult even given the advances in the field of ultrasound, CT, endoscopic pancreatography and cholangio-MRI. Another important indication is the bacteriological diagnosis of fluids, with suspected infection during the course of acute pancreatitis.

Diagnostic puncture of the pancreas is usually performed using a small-caliber needle which passes through the liver, stomach and intestines in anterior approaches. These organs are usually spared in the posterior approach. Distention or retention of intestinal contents are contraindications for passing though the digestive tract. When peripancreatic lymphoma is suspected, a biopsy needle must be used to obtain material for histological analysis.

Specific complications associated with puncture of the pancreas with a fine needle are extremely rare and include pancreatic or mesenteric haematoma, acute pancreatitis and biliary peritonitis.

Sensitivity of puncture of the pancreas varies between 71 and 87%, while specificity of the technique ranges from 84 to 100%, values that are higher than those of intraoperative biopsy. The diagnostic accuracy of the cytological study in neoplasia of the pancreas ranges from 65 to 95%.[1]

Adrenal gland and kidney

While the adrenal gland is a common site of occurrence of metastases, in patients with a known neoplasia, a mass in the adrenal gland is a metastasis in only about 40 to 50% of cases.[1] For this reason, one of the main indications for puncture of the adrenal gland is a differential diagnosis between a unique metastasis and a non-functioning adenoma, which is a very common entity (1.4 to 7.9% of the general population). Another indication for adrenal puncture, though much less frequent, is a suspicion of tuberculosis.[3]

When a diagnosis of functioning adenoma is based on clinical and laboratory data, adrenal puncture is not indicated. The most important associated contraindications are phaeochromocytoma, due to the risk of a hypertensive crisis and hydatid cyst. However, puncture of the phaeochromocytoma can be undertaken with the appropriate cardiological safeguards in place.

The type of needle to be used depends directly on the direction of approach (posterior, lateral or anterior) and the type of lesion to be punctured. Biopsy needles are reserved for cases of lesions that cannot be identified by their biological behavior, or when there is a suspicion of metastasis of unknown origin.

Specific complications associated with puncture of the adrenal gland include pneumothorax in transpleural approaches, hypertensive crisis, and acute pancreatitis.[1]

Sensitivity of this technique ranges from 80 to 100% and specificity ranges from 97 to 100%.[3]

The puncture of renal masses is only very rarely necessary because in most cases, surgery is indicated. Even when puncture is indicated, for example, in cases of cysts of unknown nature, it can be performed with ultrasound support. Nevertheless, cases of small lesions, lesions not visible using ultrasound, and lesions close to major blood vessels or to the upper pole of the kidney, are indications for CT-guided puncture.[2]

As in the case of the adrenal gland, the type of needle used depends upon the chosen approach and the type of lesion suspected.

The most frequent complications of renal puncture are subcapsular renal or perirenal haematoma, hematuria, urinoma and pneumothorax.

Based on results obtained with aspiration needles, the sensitivity of the technique varies between 82 and 85%, with specificity of between 87 and 97%[3].

Retroperitoneum

CT is the method of choice for guiding puncture of the retroperitoneum. The major indications include: staging of a known neoplasia, suspicion of lymphoproliferative disease, suspicion of the recurrence of a tumor and primary sarcoma.[1]

Suspected phaeochromocytoma, aortic aneurisms, especially if thrombosis is present, and hydatid cysts are among the main contraindications.

Needle choice depends upon the approach route and the type of lesion. In cases where the origin of the mass is unknown or lymphoma is suspected, it is convenient to use biopsy needles to obtain a histological diagnosis.[1] In situations of metastatic tumor of a known neoplasia or in post-treatment follow-up of tumors where the retroperitoneum is involved, aspiration needles can be used.

Complications are rare in posterior paravertebral

approaches. Although bruising may occur, it rarely requires specific treatment. Hypertensive crisis may occur following the puncture of a phaeochromocytoma. In anterior approaches, possible complications include acute pancreatitis.

For diagnoses of malignancy, punctures with aspiration needles have sensitivity of between 68 and 85%, with specificity of 100%.[3] The use of biopsy needles has sensitivity of 100% for diagnosing malignancy and 93% for diagnosing the nature of primary tumors.[3]

Pelvic cavity

Although all pelvic masses can be approached with CT guidance, this is usually reserved for deep lesions of the pelvic cavity that are difficult to access via ultrasound.

The puncture of cystic lesions of the ovaries is considered a contraindication, due to the risk of dissemination of the tumor.[3]

While an anterior approach using aspiration needles is possible, the posterolateral approach is generally preferred, as it avoids passing through the digestive tract and the bladder and enables the use of biopsy needles.[3]

Bruising is the most common complication, although generally without clinical significance. In transvesical punctures, hematuria can also occur. Neurological lesions are possible in cases of large-caliber needles inserted by the posterolateral route.

For diagnoses of malignancy, punctures with aspiration needles have sensitivity of between 70 and 78%, increasing to between 95 and 100% when biopsy needles are used.[3] Specificity of the technique is 100%.[3]

Osteoarticular apparatus

There is a vast number of indications for the percutaneous puncture of the bone, whether primary tumors, metastases or infections.[2] Only tumors with surgical indication are not indicated for puncture. CT-guided punctures are particular important in the spinal column.[3]

Coagulation disorders are the only major contraindication.[3]

Needle choice depends, once again, on the approach route to be used and the suspected diagnosis; sometimes it is necessary to use a special type of bone-cutting needle, coupled to a bone drill.

Possible complications include bruising, fracture of the long bones when bearing weight following the biopsy, and neurological lesions.

CT-guided percutaneous puncture of the bone is a precise and reliable method, with an average reported sensitivity of 80% and specificity of 100%.[3]

When the puncture of muscles or joints is required, ultrasound is generally used.

Therapeutic percutaneous punctures

Percutaneous drainage

Aspiration and drainage of fluids is a logical extension of the method used to accomplish diagnostic punctures. Although abscesses are the most common indication,[5] CT can also guide aspiration and/or drainage of biloma, pseudocysts, pancreatic fluid, empyema, haematomas, urinoma, lymphoceles[1] or even decompression of the bile or urinary tracts.[2]

In the drainage of superficial abscesses, ultrasound provides the same information as CT, with the advantages inherent to that form of imaging. However, in situations where there is interposition of air (chest, intestines), bone or surgical wounds, CT is as the method of choice.

Drainage of percutaneous abscess tends to be more successful when the fluid is well-defined and unilocular.[1] However, less favorable situations such as cases of fluid that is multilocular, ill-defined or made up of necrotic tissues, can be accessed using this method, particularly when the patient has a high surgical risk.

Generally, the shortest and most direct route is chosen, trying to avoid structures like the intestinal loops (particularly when there is a risk of infecting a potentially sterile fluid collection), large blood vessels and visceral masses. The needle placement technique is identical to that used for diagnostic puncture. Current practice is to collect a small quantity of material for cytological and bacteriological analysis.

When post-aspiration drainage is indicated, in order to drain the site as completely as possible, a guide wire is inserted, along which an appropriate drainage catheter is positioned, generally of considerable caliber, to guarantee appropriate drainage.

Percutaneous drainage of pancreatic pseudocysts, although controversial, may be indicated, especially in situations where infection is suspected. Guided puncture in these cases, besides contributing decisively to a diagnosis, allows placement of a drainage catheter.[1,5] This type of approach may also be an alternative to

surgery for draining symptomatic pseudocysts.[1,5]

Drainage of abscesses minimizes the handling of the infected cavity, reducing the risk of sepsis, avoids the risks of surgery and anesthesia, and saves time and resources. Abscess drainage success rates of 80 to 90% are reported, with complications occurring in 10 to 15% of cases.[1] Complications include hemorrhage, skin infection, bacteremia, empyema and perforation of the intestine. The mortality rate is less than 1%.[1] Recurrence following successful drainage occurs in less than 5% of cases.[1] According to some authors,[1] the figures presented compare favorably with those reported for surgery, which has a mortality rate of 10 to 20% and a recurrence rate of 15 to 30%. The hospitalization time is shorter (an average of 11 in cases of percutaneous drainage versus 21 days for surgery).

Decompression of the bile ducts and urinary tracts

Ultrasound and x-ray are the methods of choice for performing bile duct and urinary tract decompressions and for the placement of percutaneous nephrostomy catheters. However, CT can serve as a guidance method when these do not permit.

Neurolysis[1]

For many years, celiac plexus blocks were used for pain that was unmanageable by medical treatment, particularly in cases of pancreatic cancer. Although this procedure had usually been performed with x-ray support, CT, using a technique similar to that described for diagnostic punctures where an alcohol injection in administered to achieve analgesia, has proven to be particularly useful.

Pain relief has been reported in 30 to 90% of cases, although it is difficult to quantify the effect since it is based on subjective data. Complications include reduced muscle strength and numbness in the region between vertebrae D10 and L2, impotence, vesical retention and orthostatic hypotension. While the data on frequency of complications is not yet available, the rate is thought to be less than the 5% reported for x-ray guided procedures.

Resection of osteoid osteomas

In selected cases, and using the appropriate instruments, CT-guided osteoid osteoma resection can be performed, as in the case of juxta-articular locations where surgery may involve opening the joint capsule, with resulting consequences in terms of postoperative recovery of the patient. ■

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