REVIEW ARTICLE

Ultrasonography-guided Percutaneous Interventional Procedures of the Spleen

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Since the introduction of real-time ultrasonography (US) to the medicine in late 1970s, the unique benefit of the real-time cross-sectional imaging has made US one of the most widely used imaging modalities to guide interventional procedures. Among the intra-abdominal solid organs, the spleen is the least common solid organ considered for interventional procedures. Although splenic puncture for splenoportography was performed as early as the 1950s and has had a low complication rate, traditionally a direct splenic puncture is still avoided due to the risk of hemorrhage or laceration. US-guided percutaneous drainage of splenic abscesses has been used as a safe alternative procedure for more than 20 years, however, only a few series reporting such an interventional procedure have been published. This review describes briefly the usefulness, technique, safety, and the outcome of US-guided interventional procedures of the spleen.

KEY WORDS — complication, percutaneous interventional drainage, percutaneous interventional procedure, spleen, ultrasonography

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Introduction

Over the past 30 years, the growth of image-guided interventional procedures have significantly changed the role of radiologists. Initially, only those patients unsuitable for conventional treatment were submitted to the radiologist. One of the earlier interventional radiology techniques to be developed was angiography. As experience grew and the resolution of imaging modalities was improved, better results were obtained. Nowadays image-guided interventional procedures have become the treatment of choice in certain diseases. Since the introduction of real-time ultrasonography (US) to the medicine in late 1970s, the unique benefit of the real-time cross-sectional imaging has made US one of the most widely used imaging modalities to guide interventional procedures. Among the intra-abdominal solid organs, the spleen is the least common solid organ considered for interventional procedures. Although splenic puncture for splenoportography was performed as early as the 1950s and has had a low complication rate, traditionally a direct splenic puncture is still avoided due to the risk of hemorrhage or laceration [1,2]. US-guided percutaneous drainage of splenic abscesses have been used as a safe alternative procedure for more than 15 years. However only a few series reporting

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such an interventional procedure have been published to date [2–7]. This report describes the usefulness, safety and the outcome of US-guided interventional procedures of the spleen.

Ultrasonographic Anatomy of the Spleen

The spleen varies in size, weighing from 65 to 265 g. It is coffee bean-shaped and convex craniolaterally against the diaphragm and lateral abdominal wall. The spleen appears as a sickle-shaped homogeneous solid organ on US. The craniocaudal dimension (CCD) is usually below 10 cm. A CCD of 12 cm or above is considered enlargement. The anteroposterior dimension is about 7 cm and the thickness (T) is about 3–4 cm. A two-dimensional (2D) measurement by multiplying CCD and T has been suggested for estimating the size of the spleen [8]. A measurement of more than 35 cm^2 is considered enlargement. The spleen can be enlarged due to hematologic, vascular, neoplastic, inflammatory, and immunologic disorders. Storage diseases may also cause diffuse splenomegaly. Some other focal benign or malignant diseases involving the spleen may cause splenic enlargement [9].

General Techniques of Ultrasound-guided Intervention

Preparation for a percutaneous interventional procedure should always include a clotting profile, and when necessary a clotting parameter should be brought into an acceptable range before any intervention. Prior to the procedure, informed consent should be obtained from the patient. Percutaneous aspiration, biopsy, or drainage of spleen is usually performed on an inpatient basis. There should be sufficient time for observation after the procedures, e.g. 2–4 hours to ensure no significant immediate complications have occurred. Patients are closely monitored in the ward for at least 24 hours following the procedure.

The interventional procedure is performed after cautious real-time observation of the excursion of the diaphragm, pleura and the air-containing lung tissue. A puncture site on the left mid- or posterior axillary line is preferable. Either an intercostal or subcostal approach is used, whichever provides the shortest route to the target lesion. Local anesthetic is administered, and the spleen is then punctured, usually during suspended respiration, under real-time monitoring with a "free hand" technique using a 22 to 18 gauge needle. Penetration of the lung should be avoided but it is not necessary to make a special attempt to avoid the pleural recess. Color Doppler ultrasound (CDU) would be better than gray-scale US for evaluation of the target pathology and its surroundings in order to minimize the possibility of complications (especially injuries to the hilar vessels).

Percutaneous Aspiration and Biopsy

A number of benign and malignant diseases involve the spleen in either a focal or diffuse manner [10]. Noninvasive imaging techniques such as US, computed tomography (CT), magnetic resonance imaging (MRI) and scintigraphy are used to diagnose the presence and nature of splenic lesions. An accurate pathological diagnosis is important both for planning treatment and predicting prognosis [1,10–12].

Almost any tissue can now be aspirated or biopsied percutaneously. The best imaging for guidance of splenic intervention is US. The spleen can be scanned in a multi-planar fashion in almost any scanning plane. This makes US a better modality than CT for being able to avoid penetrating the left lung or vascular structures. Needle penetration of the diaphragm will usually cause no problem.

Most authors have recommended a cranially angulated approach via the subcostal route for upper polar splenic lesions in an attempt to avoid pleural injury and resultant pneumothorax. However, we made no special attempt to avoid the pleural recess [6]. The high intercostals route can be safely used for aspiration and biopsy of upper polar splenic lesions. It is possible that clinically insignificant pneumothorax could have been missed in a small number of patients [1,5].

Choice of Aspiration or Biopsy

The needles

The tissue sample may be aspirated, cored, or resected. The needle size used in spleen lesion is most commonly from 22 to 18-gauge. Accuracy is directly related to the size and amount of tissue samples obtained, but the complication rate is obviously higher with larger bore needles. Fine needle aspiration (FNA) cytology or biopsy can be performed simply using a 21 to 22-gauge spinal needle (9.8 cm length) or preferably 21 to 22-gauge percutaneous transhepatic cholangiographic (PTC) needle (15–20 cm, Hakko Electric Machine Works Co, Togura, Japan). The latter has better elasticity of the needle shaft and provides better visualization of the needle on US. Core tissue can be sampled with a cutting edge needle (e.g. EZ needle® E-Z-EM, Westbury, NY, USA) or a resecting needle (e.g. Temno Needle®, Bauer Medical International, SA, USA). Better results have been obtained with a resecting needle based on our previous experience [9,10].

The Splenic Pathologies

Lymphoreticular malignancies are the most common neoplasms involving the spleen, and several studies have confirmed the efficacy of splenic FNA in diagnosing these lesions [10,13–17]. However, its role is still controversial because subtyping of the lymphomas is not always accurate on FNA biopsy alone [13,18]. Splenic core biopsies have been advocated to improve tissue sampling but the safety and efficacy of this technique is still not proven [19,20]. Splenic FNA biopsy was advocated to be a useful procedure in the diagnosis of lymphoma. Venkataramu et al found seven new cases of lymphoma and two cases of recurrence of lymphoma were correctly diagnosed, although further subtyping was not possible [21]. Recent studies have shown that splenic FNA using cell surface markers and immunophenotyping is very accurate for the diagnosis and subtyping of lymphomas [22–26].

Focal splenic lesions in patients with lymphoreticular malignancy do not always represent a neoplastic process and an infective focus is possible because of the immunosuppressed status of these patients. Splenic tuberculosis can also be encountered in immunocompetent patients or patients with acute leukemia undergoing chemotherapy and may be of a miliary or macronodular variety [27–29]. Splenic biopsy has previously been shown to be a sensitive technique for establishing the diagnosis of splenic tuberculosis [30]. The high incidence of tuberculosis in Bailey's series is attributed to the overall high prevalence of tuberculosis in India [31]. Acid fast stain and culture for tuberculosis should be attempted in some endemic regions.

Since the echotexture of the splenic sarcomas (such as Kaposi's sarcoma or lymphoma) can be uniform throughout, splenic aspirate may show only an inflammatory infiltrate in some patients whose histopathology of the spleen demonstrates scattered areas of neoplastic cells with intervening areas of inflammatory cells. This might result in an inadvertent sampling error. Previous studies have also reported false negative results with splenic FNA biopsy, with the incidence varying from 0.06% to 2% [10,13]. A negative FNA does not therefore always exclude pathology and should be followed by repeat biopsies or alternative procedures to establish a definite diagnosis.

Percutaneous Drainage of Abscess

Splenic abscesses are rare, with reported incidence of 0.2% to 0.7% in various autopsy series [32,33]. Splenic abscesses may occur due to previous trauma or contiguous infection but are usually due to hematogenous spread, with infective endocarditis being a common source. Other predisposing factors include malignant hematological conditions, hemoglobinopathies and immunosuppression [6]. Immunocompromised individuals are highly susceptible to various infections with fungi, *Mycobacterium tuberculosis, Pneumocystis jerovici* and bacteria such as Staphylococcus and Streptococcus [34,35]. No organisms may be identified in 11–20% of patients, particularly in patients undergoing antibiotic therapy.

Antibiotic treatment and splenectomy is the conventional therapeutic method which carries a relatively high mortality (up to 14% in the elderly) and morbidity with a risk of overwhelming post splenectomy sepsis [33,34,36]. A spleen preserving strategy is currently being followed in cases of trauma and benign lesions.

Usually, direct cross-sectional imaging using US will clearly show the location and extent of fluid collection within the spleen. However, if there is any doubt with the US appearance, a fine needle (e.g. 21–22 gauge) puncture and aspiration may be applied for a definitive diagnosis of the abscess prior to a more invasive drainage procedure. Typically, a larger abscess shows an irregular wall, weak or no internal echoes. It is generally ovoid or round in shape and accompanied by mild to moderate acoustic enhancement. Wedge-shaped abscess is mainly seen in patients with infectious endocarditis and septic emboli. Microabscesses, presenting as multiple or numerous tiny hypo- or anechoic lesions in the spleen, are typically seen in fungal infections occurring in an immunosuppressed state, and are occasionally seen in tuberculosis [6,37,38]. Microabscesses with a "wheel-within-a-wheel" pattern have been described in cases of fungal infection [39].

Drainage Technique

When an abscess is identified in the spleen, a safe access route to the lesion should be carefully searched and evaluated using US. An 18-gauge sheathed puncture needle is used first to aspirate the fluid-containing space. If pus can be aspirated, then a catheter is inserted using the Seldinger method under US guidance. If the abscess cavity is too small for a drainage procedure, then only aspiration is done. The patient is then followed by US regularly at 2 to 4-day intervals in the first 2 weeks. Serial follow-up US is done after discharge for at least 3 months. Patients with abscesses greater than 33–4 cm in diameter are suitable for percutaneous drainage with Seldinger method or trocar method using an 8 to 9-F pigtail catheter. In an enlarged spleen with an abscess in the middle part or lower pole, the procedure can be completed without difficulty. However, in a spleen of borderline size or with a cephalic lesion (upper pole), a lower puncture site in the intercostal or subcostal space is selected. If necessary, manually compressing the skin and soft tissues and bending the needle may assist in gaining safe access to the splenic abscess [6,10]. The procedures are performed after cautious real-time US evaluation, and observation of the excursion of the diaphragm, pleura, and the air-containing lung. A puncture site on the mid- or posterior axillary line was preferred. Soon after catheter insertion, the local condition should be checked with US, and then followed every 2 to 4 days. The abscess was aspirated manually as completely as possible using a 20 mL syringe on the first day. The cavity is usually noted to decrease in size, and symptoms are either improved or totally disappear within 2 to 3 days. Patients with a detached catheter or having a recurrent abscess after removal of the first catheter can be treated with another drainage session. Catheterization can be continued for 7 to 19 days. The catheter can be removed if the daily abscess drain output is less than 3 mL for 2 days and the greatest diameter of the abscess cavity was less than 2 to 3 cm. The abscess drained should be also sent for smear, culture, and sensitivity tests. Antibiotic coverage on the bacteria should be used after sensitivity tests for the specific bacterial culture obtained.

Causes of Incomplete Drainage

The success rate for CT or US-guided percutaneous drainage of splenic abscesses was around 76%, as reported by Quinn et al, and was slightly lower than that for percutaneous drainage of other intra-abdominal abscesses (80–90%) [40,41]. However, in recent reports the success rates have been higher, up to 100%, although several catheterizations may be needed to achieve curative drainage [6,42].

Image-guided percutaneous catheter drainage of splenic abscesses have been recently reported to be a safe and effective alternative to surgery with success rates ranging from 51% to 100% with associated complication rates of 0% to 18% [6,34,36]. The success of percutaneous drainage depends upon various factors such as unilocular or multilocular abscesses, the presence of a discrete wall or septations, and the number of abscesses. Percutaneous drainage of multilocular and multifocal abscesses has a lower success rate [6,43].

The causes of incomplete or failed drainage include multilocular abscess cavities and phlegmonous or thick necrotic material unable to drain. Drainage is actually not indicated for microabscesses. Aspiration for bacteriological studies and cultures followed by a broad spectrum of antibiotic coverage is generally recommended in this instance. A necrotic tumor may simulate an abscess. If a trial of drainage is not successful, cytological or histological study obtained from the lesion is mandatory to rule out this possibility.

Various series regarding either ultrasound or CT guided percutaneous splenic interventions have reported. Successful CT-guided drainage of seven splenic abscesses including one multilocular abscess without complications was reported by Thanos et al [34]. In another series of seven patients, technically successful catheter placement in 100% and a complete drainage rate of 86%, with a complication rate of 0.3% has been reported [36]. Most series reported perform the majority or all of the procedures under US guidance, however CT was used only when the lesion was not well visualized on US. In general, the advantage of real time visualization of the needle in multiple planes may shorten procedure and anesthesia time then reasonably lower the complication rate.

Complications of US-guided Splenic Intervention

The complication rate of US-guided splenic intervention depends on the size and number of the sample obtained, the likelihood of vessel damage, the nature of the pathology, and the location of the lesion. The complications following percutaneous splenic interventions are rare, with primarily hemorrhage though a puncture of the pleura, colon or kidney being reported. The reported incidence in literature of hemorrhage following splenic biopsy is between 0% and 2% [1,13,36]. Moreover, in a series of 23 patients who underwent splenectomy soon after FNA biopay, Solbiati et al reported that no intrasplenic hematomas were seen. No one is associated with the spread of malignancy [13]. Nearly all complications are related to hemorrhage which may in part dependent upon the site and vascularity of the lesion. Bleeding is usually clinically insignificant and can be demonstrated on US or CT immediately following the interventions but it does cause flank pain. A small perisplenic hematoma could occasionally be seen following FNA biopsy which did not require any surgical intervention. No deaths occurred following interventional US procedure in our experience (Table). However, significant bleeding with hypovolemia requiring blood transfusion has been encountered using a resecting needle in one patient after core needle biopsy of a splenic hemangioma which showed an atypical US feature.

Table. Complications of Interventional US of the Spleen

Procedures	No.	Complications (%) outcome
FNA cytology	89	2 (2.2)
Core needle biopsy	54	4* (7.4)
Abscess drainage and/or aspiration	34	1 (2.9)
Total	177	7 (4.0)

**Only one case (1/177, 0.6%) was associated with serious bleeding and hypovolemia requiring blood transfusion.*

The other three patients showed only minimal subcapsular or perisplenic hematomia. A recent study by Lucey et al showed that the location of the lesion, whether central or peripheral, did not significantly affect the complication rate. However, it has been advocated by Kang et al that performing biopsies on peripherally located lesions which involve traversing the least amount of normal splenic parenchyma may minimize the risk of hemorrhage, and if lesions are present in both the spleen and another organ which are amenable to biopsy, it may be safer to sample the non-splenic lesion first to avoid potential hemorrhagic complications of splenic biopsy [44]. Complications such as pneumothorox, pyothorax, bowel perforation and local cutaneous seeding have not been noticed in our series.

Conclusion

US is useful in providing guidance for interventional procedures of the spleen such as FNA cytology or biopsy. It helps to assess the splenic size and guide the needle along the shortest route to the lesion. It also helps in avoiding inadvertent injury to blood vessels in and adjacent to the splenic hilum, particularly in patients with a normal sized or small spleen. US provides real-time guidance for continuously monitoring the needle tip so that appropriate areas can be sampled, and a safe access route for drainage can be obtained. This is an advantage over CT-guided interventions because the spleen moves with respiration. A free hand technique is preferred as it offers considerable flexibility to the interventionist, allowing him or her to perform fine adjustments while maneuvering the needle.

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