US-guided splenic interventional procedures in pediatric patients: How to do it and what to expect

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Learning objectives

- Revise all ultrasound (US) guided splenic interventional procedures performed in children from 2002 to 2013 (n=10).

- Describe the different techniques emphasizing the peculiarities of pediatric patients, common indications and techniques employed.

- Detail results and complications.
Background

The spleen is a lymphoid organ frequently affected in children diseases including malignancy such as lymphoma, or infections (fungal, tuberculosis, parasitic). In these cases imaging shows nonspecific changes and complementary diagnostic tools are required. Tissue samples may be needed and can be obtained by percutaneous biopsy [1-2].

Interventional procedures in pediatric patients can also be therapeutic like fluid aspirations or drainage.

Transplenic splenoportography (TSSP) is a diagnostic interventional procedure that is seldom performed in children with portal hypertension to show collateral flow and design individualized treatments [3].

Pediatricians have traditionally been reluctant to percutaneous splenic access due to a supposed increased bleeding risk as opposed to surgery. However, some series in the last 20 years have demonstrated its safety and diagnostic value (ranging between 84 and 90%) [4].
Findings and procedure details

We review interventional procedures in pediatric patients with suspected splenic/perisplenic pathology between June 2002 and November 2013.

The techniques include core and fine-needle aspiration/biopsy (n=6), percutaneous drainage for splenic fluid collections (n=3) and TSSP (n=1).

Indications for biopsy were post-transplant lymphoproliferative disorder (n=2), fever of unknown origin (n=2), benign mass (n=1) and bicytopenia and splenomegaly (n=1). TSSP was performed to confirm the presence of a splenorenal shunt not clearly depicted by MR, US and CT in a patient with hypersplenism and portal cavernomatosis (n=1).

Figures 1 and 2 summarise the main data from the patients.

1) Indications and contraindications of Splenic interventional procedures

Interventional procedures in children are usually performed after abdominal US, computed tomography (CT) or MRI so that the interventional radiologist has as much information as possible to make a suitable patient’s selection, plan the procedure and avoid complications.

Incidental splenic focal lesions are usually benign. In most instances sampling is not necessary and follow up suffices to confirm a benign lesion. The most common benign splenic lesions are cysts, hemangiomas, or hamartomas (Figure 3) [5].

Sampling of neoplastic lesions either primary or metastatic is compulsory for planning the therapeutic work-up [6]. Pediatric Hodgkin lymphoma has an incidence of 1.2 per 100,000 and represents the most common malignancy in adolescents in high-income countries [7-8]. Splenic involvement is crucial to stage disseminated disease (stage IV of Ann Arbor staging classification) as it changes prognosis [9] and treatment. In patients in whom a diagnosis of lymphoma has already been made, evaluation of new splenic lesions may be required to differentiate residual disease, necrosis, infection, or transformation to a higher grade lymphoma.

Splenic metastatic lesions are due to classically adult’s primary malignancies including breast, lung, ovary, and colon. They are extraordinarily rare in pediatric patients.
Splenic abscesses are uncommon in children, however it should be considered in patients treated with immunosuppressant therapies or after abdominal surgery. Biopsy may be considered in these cases to obtain histological or microbiological confirmation. Traditionally, splenic abscesses have been drained surgically with relative high morbimortality whereas success rates for percutaneous drainage range from 60% to 77% with significant lower morbimortality [10]. Percutaneous drainage for splenic fluid collections is better tolerated because of the use of smaller sized catheters (Figures 4 and 5).

Splenic biopsy is sometimes required in the flow chart for fever of unknown origin in cases where other tests have been negative (Figure 6). In these patients visceral leishmaniasis should be considered in endemic countries and can be demonstrated in splenic tissue (Figure 7) [11]. It is also indicated in the assessment of splenomegaly of uncertain cause in the absence of a focal lesion which can be caused by extramedullary hematopoiesis [12].

Langerhans' cell histiocytosis is rare cause of focal splenic lesions that should be considered in the differential diagnosis of splenomegaly with hypoechoic splenic masses (Figures 8 and 9) [13].

Muraca et al. proved in their case series that all conclusive results of US-guided core biopsy of the spleen changed patient management [14].

TSSP is an invasive yet relatively safe procedure for evaluation of paediatric portal system. TSSP is seldom used in pediatric portal hypertension due to the existence of other less invasive diagnostic procedures like CT or MRI [15-16]. Nevertheless TSSP can be used to provide dynamic information about the portal venous flow and to demonstrate portosystemic shunts (Figure 10). Portal hypertension is the commonest cause of upper gastrointestinal hemorrhage in children. Patients with portal cavernomatosis and digestive bleeding may require surgical shunts after resolution of the acute disease when there are not spontaneous shunts [17].

It has not been described yet absolute contraindications of the procedures in pediatric children. Nevertheless, uncorrectable coagulopathy and hemodynamic instability should be corrected before any intervention. Ascites is a relative contraindication of these techniques.

2) Preparation

All patients should have normal clotting parameters, using the same criteria as in adults. Laboratory evaluation includes haemoglobin levels, platelet count and determination of
prothrombin and partial thromboplastin times. As many of the patients who undergo splenic biopsy have pancytopenia, platelet counter should be at least greater than 50,000/mm³. In our case only one patient needed platelet transfusion to correct abnormal bleeding parameters.

Clinical conditions and coagulation tests are relevant in needle selection (25G/16-18G) and in the number of samples.

Informed consent has to be obtained before any intervention. It is especially important to inform the parents about the possibility of haemorrhage with potential need of blood transfusion or even emergent splenectomy in cases of severe haemorrhage.

While local anesthesia is usually adequate for adults, all pediatric procedures were performed and under general anesthesia. It is very useful that the anaesthesiologist reduces as much as possible the respiratory motion. The patients are placed in supine position. Blood pressure, heart rate, oxygen saturation level, and electrocardiogram were monitored. All patients must have at least one intravenous line. Emergency resuscitation equipment should always be present in the room.

All the members of the staff have to work in aseptic conditions. Once the lesion is localized, the overlying skin is cleaned and draped. US transducer has to be covered with a disposable cover (Figure 11).

3) Techniques

The procedure is performed with real-time sonographic guidance. We use high resolution (5-10MHz) lineal ultrasound scan. Color Doppler is used to avoid injuring the major vessels surrounding the lesion.

We choose the shortest and straightforward trajectory to the lesion with longitudinal images of the needle pathway whenever possible. Normal splenic parenchyma should surround the biopsy tract to prevent subcapsular or peritoneal hematoma. When there is a normal appearance or diffuse infiltration of the spleen, we normally prefer the periphery of the superior pole.

Freehand technique with intercostal approach is the most common technique. Subcostal approach is preferred when there is splenomegaly.
Careful planning of the technique, number of samples needed already agreed with the pediatric pathologist or cytopathologist can avoid unnecessary passes with an adequate diagnostic accuracy.

There are some specific aspects of the splenic procedures that we consider in the following paragraphs:

a. Splenic biopsy

Splenic sampling can be performed using fine-needle aspiration or core-needle. Fine needle biopsy in children can be performed using a 23- or 25-gauge needle. Core-needle biopsy is performed using 16- or 18-gauge needles.

Larger needle are related to higher bleeding rate without providing better results.

The choice of one another depends on the clinical conditions, individual risk of bleeding and suspected diagnosis. So, in cases of coagulopathy we prefer using a 20- to 23- gauge Chiba needle (lower diagnostic accuracy compared to core biopsy) while in suspected lymphoproliferative disorders, we use 16-18 gauge needles so that we can make an immunohistochemical analysis and flow cytometry.

The number of passes depends on the analysis needed (microbiology, cytology or histology).

Autologous clot or gelfoam can be introduced through the inserting cannula at coaxial procedures if the patient has altered coagulation parameters or if we see a splenic hematoma during the procedure.

A meta-analysis showed a sensitivity of 86.8% (95% confidence interval [CI], 78.2 to 92.4) and specificity of 96.8% (95% CI, 90.4 to 99) for core biopsy alone, and a sensitivity of 84.1% (95% CI, 77 to 89.3) and specificity of 92.5% (95% CI, 35.6 to 89.4) for fine-needle aspiration [4].

b. Aspiration and drainage

The spleen is an uncommon site for infection. The most frequent causes are tuberculosis, fungal, and bacterial. Parasitic infection should be considered in endemic regions.

Aspiration alone is considered when the fluid collection is < 3 cm³.

We recommend the Seldinger technique selecting 8.5 to 12 F pigtail catheter for drainage of collections >3 cm³. Before placing the catheter, an aspiration is needed to perform microbiologic analysis.
If the collection is multiseptated, flushing 2 to 5 times the catheter with sterile saline can make drainage easier (Figures 5, 15 and 16).

The catheter can be removed when there is resolution of the clinical signs of infection (fever, disappearance of leucocytosis…) or when there is <10 mL drainage in a 24-hour period. US should be performed after the catheter removal to ensure there is no residual collection.

c. TSSP

The spleen is punctured with a 21-G needle under US guidance. Iodinated contrast is injected and the digital images obtained. If the presence of splenorenal shunt remains unclear after the first injection, a second one can be performed nearer the hilum.

4) Postprocedure Management

Close follow up has proved to reduce morbi-mortality of the procedures described.

All the patients are sonographically examined right after the procedure to detect complications such as intrasplenic, subcapsular or perisplenic hemorrhage. If these findings are positive or inconclusive we repeat the US a few minutes later to confirm or demonstrate some hematoma growth. In these cases checking the haemoglobin levels and blood pressure is necessary to decide further treatments.

The patients are observed in the post-operative care unit for 2 to 4 hours checking the patient’s vital signs and level of pain.

Parents are instructed to detect alarm signs and how to prevent movements which can potentially increase bleeding risk.

5) Safety and Complications

The most common complications after performing the techniques previously described include intrasplenic hemorrhage or hemoperitoneum. Injury to pleura and the left lower lobe (pneumothorax), the colon (pneumoperitoneum) and the left kidney are reported less frequently in the literature [18].

The meta-analysis previously mentioned showed an overall complication rate of 4.2% for splenic biopsy. Biopsies undertaken with a 14-gauge needle had an overall complication rate of 3.9% while biopsies performed with needles 18 gauge or smaller has a major
complication rate (1.9%). This is comparable with that for other abdominal solid organs such as liver (0.5 to 3.3%) or kidney (0.7 to 6.3%).

Fine needle biopsy has also favorable complication rate compared with splenectomy (Figure 12) [4]. Splenectomy has a diagnostic accuracy likely higher compared with percutaneous image-guided biopsy but post-splenectomy patients have increased risk of a streptococcal infection [19-20]. The risk of sudden fatal sepsis in children is particularly high.

Percutaneous drainage of a splenic abscess has a reported success rate of 80 to 100% [21-22]. Internal septations can reduce the success.

The complications can be classified as major or minor attending to Society of Interventional Radiology guidelines (Figure 13) [23]. Our experience shows that the techniques described are safe with minor complications such as small intrasplenic, subcapsular or perisplenic haematomas, which are asymptomatic post-procedures (Figure 14). There were no major complications. None of the children needed transfusions, emergency splenectomy after the procedure or ICU hospitalization.
<table>
<thead>
<tr>
<th>AGE/SEX</th>
<th>INDICATION</th>
<th>US IMAGE</th>
<th>PROCEDURE/TECHNIQUE</th>
<th>RESULTS</th>
<th>MINOR COMPLICATIONS/MAJOR COMPLICATIONS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2y 10m/M</td>
<td>Lymphoproliferative disorder after liver transplantation</td>
<td>Diffuse nodular pattern</td>
<td>Fine-needle aspiration biopsy (25G) Core biopsy (18G)</td>
<td>No evidence of malignancy</td>
<td>Small-volume perisplenic blood/0</td>
</tr>
<tr>
<td>1y 11m/M</td>
<td>Fever of unknown origin</td>
<td>Homogeneous hepatospleno-megaly</td>
<td>Core biopsy (18G)</td>
<td>Visceral leishmaniasis</td>
<td>Small-volume hemoperitoneum/0</td>
</tr>
<tr>
<td>2y 10m/M</td>
<td>Fever of unknown origin after liver transplantation</td>
<td>Normal splenic appearance</td>
<td>Core biopsy (16G)</td>
<td>No evidence of malignancy</td>
<td>Intrasplenic hematoma/0</td>
</tr>
<tr>
<td>3y 3 m/M</td>
<td>Splenic benign mass</td>
<td>Hyperechoic nodular mass</td>
<td>Core biopsy (18G)</td>
<td>Non specific mesenchymal proliferation</td>
<td>0/0</td>
</tr>
<tr>
<td>1y 2 m/F</td>
<td>Fever of unknown origin Suspected histiocytosis</td>
<td>Normal splenic appearance</td>
<td>Core biopsy (18G)</td>
<td>No evidence of malignancy or infectious disease</td>
<td>0/0</td>
</tr>
<tr>
<td>1y 9 m/F</td>
<td>Bicytopenia and hepatosplenomegaly</td>
<td>Splenomegaly. Hypoechoic lesions</td>
<td>Core biopsy (18G)</td>
<td>Langerhans cell histiocytosis</td>
<td>0/0</td>
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**Fig. 1:** US-guided splenic biopsies performed in pediatric patients between 2002 and 2013. (*=see table 4)

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<table>
<thead>
<tr>
<th>AGE/SEX</th>
<th>INDICATION</th>
<th>US IMAGE</th>
<th>PROCEDURE/TECHNIQUE</th>
<th>RESULTS</th>
<th>MINOR COMPLICATIONS/MAJOR COMPLICATIONS</th>
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</thead>
<tbody>
<tr>
<td>1y 10m/F</td>
<td>Abscesses in patient with bacterial peritonitis</td>
<td>Perisplenic fluid collection (4x3 cm)</td>
<td>20G needle aspiration</td>
<td>Microbiological culture: Escherichia coli Enterococcus faecalis Bacteroides fragilis</td>
<td>0/0</td>
</tr>
<tr>
<td>7y 2m/M</td>
<td>Abscess in patient with appendectomy and peritonitis</td>
<td>Epigastric and subcapsular fluid collection (12x7 cm) Splenomegaly</td>
<td>Pigtail catheter (10F)</td>
<td>Microbiological culture: Escherichia coli</td>
<td>0/0</td>
</tr>
<tr>
<td>12y 10m/M</td>
<td>Abscesses in patient with appendectomy and peritonitis</td>
<td>Perisplenic fluid collection (8 x3 cm)</td>
<td>Pigtail catheter (10F)</td>
<td>Microbiological culture: Escherichia coli Bacteroides fragilis</td>
<td>0/0</td>
</tr>
<tr>
<td>11y 2m/M</td>
<td>Portal hypertension Portal cavernomatosis</td>
<td>Splenomegaly</td>
<td>Splenoportography</td>
<td>Small and tortuous splenorenal shunt</td>
<td>0/0</td>
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</tbody>
</table>

**Fig. 2:** US-guided perisplenic fluid collections aspiration and drainages and splenoportography performed in pediatric patients between 2002 and 2013. (*=see table 4*)

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Fig. 3: Splenic biopsy in a 3 year-old boy with incidental splenic lesion. (a) T1-weighted MRI demonstrates a hypointense well-defined splenic mass. (b) In T2-weighted MRI, the mass is hyperintense. (c) US performed six years later demonstrates a small residual lesion in the spleen. (d) Photomicrograph (original magnification, x 1000; hematoxylin-eosin [H&E] stain) showed a nonspecific mesenchymal proliferation. (Department of Pathology, Hospital Universitario 12 de Octubre/Madrid 2006).

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Fig. 4: Perisplenic drainage in a 7-year-old boy with perisplenic abscess after appendectomy and peritonitis. (a) Abdominal US showed multilobed collection around the spleen. (b) US-guided aspiration. (c) 10F catheter drainage was placed. (d) US repeated two weeks after the procedure showed a small-volume perisplenic fluid collection.

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Fig. 5: (a), (b) and (c) show Seldinger technique for abscess drainage in patient described in Figure 4. (d) demonstrates a small-volume residual collection.
Fig. 6: Splenic biopsy in a 1-year-old girl with fever of unknown origin. Abdominal US shows hepatomegaly (a) and splenomegaly with no focal lesions (b). (c) US-guided fine-needle aspiration and core biopsy demonstrated no malignancy or infectious diseases that justify the fever. (d) US repeated four weeks after biopsy showed splenomegaly.

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Fig. 7: Splenic biopsy in a 23 month-old girl with fever of unknown origin. Photomicrograph (original magnification, x 1000; H&E stain) shows histiocytes with intracellular parasites (asterisk). The diagnosis was visceral leishmaniasis. (Department of Pathology, Hospital Universitario 12 de Octubre/Madrid 2007).

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Fig. 8: Splenic biopsy in a 21 month-old girl with bicytopenia. (a) Lateral cranium plain radiograph demonstrates lytic lesions. (b) and (c) Enhanced CT shows splenomegaly with hypodense lesions. (d) US-guided biopsy was performed to establish the diagnosis (see Figure 9).

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Fig. 9: Splenic biopsy of patient described in Figure 8. (a) Photomicrograph (original magnification, x 40; H&E stain) shows cells in the red pulp with histiocyte appearance. Immunohistochemistry demonstrates CD68 (b), CD1a (c) and S100 (d) positivity. The diagnosis is Langerhans cell histiocytosis. (Department of Pathology, Hospital Universitario 12 de Octubre/Madrid 2006).

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Fig. 10: Splenoportography in a 11-year-old boy with portal hypertension. (a) and (b) Coronal and axial T2-weighted MRI show splenomegaly and splenorenal shunt (behind the spleen). (c) Selective splenic arteriography. (d) Late arterial phase of celiac angiography. (e) and (f) Transplenic splenoportography showing tortuous splenorenal shunt (retroperitoneal and left colic veins).

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Fig. 11: Preparation before splenic interventional procedures. (a) Interventional radiologist has to work in aseptic conditions. (b) US transducer has to be covered. (c) The patient is placed in supine position and the best approach has to be chosen to reduce complications. (d) US-guided techniques have demonstrated to be safe and have high accuracy rates.

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<table>
<thead>
<tr>
<th>STUDY</th>
<th>No. OF BIOPSIES</th>
<th>MAJOR COMPLICATIONS</th>
<th>MINOR COMPLICATIONS</th>
<th>No. OF SPLENECTOMIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civardi et al (2001)</td>
<td>453</td>
<td>3: 2 hemorrhages requiring transfusion, one pneumothorax requiring chest tube</td>
<td>18: 13 pain, 2 subcapsular hematomas, 2 small hemoperitoneum, 1 vasovagal episode</td>
<td>0</td>
</tr>
<tr>
<td>Gómez-Rubio et al (2009)</td>
<td>62</td>
<td>1 hemorrhage requiring splenectomy</td>
<td>1 subcapsular hematoma</td>
<td>1</td>
</tr>
<tr>
<td>Liang et al (2007)</td>
<td>43</td>
<td>1 hemorrhage requiring transfusion</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cavanna et al (1992)</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Di Stasi et al (1996)</td>
<td>160</td>
<td>0</td>
<td>1 subcapsular hematoma</td>
<td>0</td>
</tr>
<tr>
<td>Keogan et al (1999)</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lindgren et al (1985)</td>
<td>32</td>
<td>4 hemorrhages; 3 requiring transfusion, 1 requiring splenectomy</td>
<td>16: shoulder pain</td>
<td>1</td>
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<tr>
<td>Suzuki et al (1987)</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Venkaramu et al (1999)</td>
<td>35</td>
<td>1 hemorrhage requiring transfusion</td>
<td>0</td>
<td>0</td>
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**Fig. 12:** Previous series of spleen biopsy and its complications. Adapted from "Percutaneous Image-guided Biopsy of the Spleen: Systematic Review and Meta-Analysis of the Complication Rate and Diagnostic Accuracy" [4].

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<tr>
<th>MINOR COMPLICATIONS</th>
<th>MAJOR COMPLICATIONS</th>
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<tbody>
<tr>
<td>A. No therapy, no consequence</td>
<td>C. Require therapy, minor hospitalization (&lt;48h)</td>
</tr>
<tr>
<td>B. Normal therapy, no consequence; includes overnight admission for observation only</td>
<td>D. Require major therapy, unplanned increase in level of care, prolonged hospitalization (&gt;48h)</td>
</tr>
<tr>
<td></td>
<td>E. Permanent adverse sequelae</td>
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<td></td>
<td>F. Death</td>
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**Fig. 13:** Society of Interventional Radiology Classification System for Complications by Outcome.

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Fig. 14: (a) and (b): Minor complication after core biopsy in a 2 year-old boy with suspected post-transplant lymphoproliferative disorder. (a) shows needle trajectory and (b) a small intrasplenic hematoma that did not require any therapy. (c) demonstrates a small-volume clot adjacent to the spleen as a minor complication after core biopsy in patient described in Figure 3.

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Fig. 15: Drainage becomes easier by flushing the catheter with sterile saline when the collection is multiseptated.

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Fig. 16: Drainage becomes easier by flushing the catheter with sterile saline when the collection is multiseptated.

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Conclusion

Percutaneous splenic interventions are scarce in children and US is an useful tool for its guidance. A thorough knowledge of the technique and a suitable patient selection will determine its success and safety.
References


