Blunt splenic trauma: Can contrast enhanced sonography be used for the screening of delayed pseudoaneurysms?

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A B S T R A C T

Purpose: To assess the value of contrast-enhanced sonography (CES) for the detection of delayed post-traumatic splenic pseudo-aneurysms, usually considered an indication for angiographic embolization.

Methods: Sixty-three consecutive hemodynamically stable trauma patients in whom admission CT displayed a splenic injury of grade II or higher (AAST classification), or evidence of vascular involvement, were included in the study. CES of the spleen using a second generation contrast agent was systematically performed within 48–72 h after admission, for the detection of a pooling of contrast media suggestive of pseudoaneurysm. Within 6 h after contrast-enhanced sonography, all patients underwent an abdominal CT for control purposes. CES results were compared to CT findings, which were considered the reference standard. This study received approval from the institutional ethical board.

Results: CES showed a bluish contrast consistent with a pseudoaneurysm in 6 of the 63 patients. All were confirmed at subsequent control CT. Pooling of contrast was found at CT in 2 patients in whom contrast-enhanced sonography was negative. There was no false positive CES examination for the suspicion of pseudoaneurysms. When compared to CT, the sensitivity, specificity, positive and negative predictive values of CES to suggest a pseudoaneurysm, were 75% (6/8), 100% (55/55), 100% (6/6), and 96% (55/57), respectively.

Conclusion: Our data suggest that CES may be useful for the screening of delayed traumatic splenic pseudoaneurysms: if a negative CES does not absolutely rule out a pseudoaneurysm, a positive CES warrants an angiography, without need of control CT.

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1. Introduction

The spleen is the most commonly injured organ in blunt abdominal trauma patients. Non operative management (NOM) has become the mainstay of the treatment of blunt splenic trauma, because it allows for preservation of the immune splenic function, prevents postsplenectomy sepsis and avoids complications associated with laparotomy [1]. Some retrospective studies reported that, without specific treatment, the rate of failure of NOM was higher when CT showed a pooling of contrast media within the spleen parenchyma than when it did not [2,3]. Comparative series between CT and arteriography showed that a pooling of contrast on CT, defined as a “hyperdense focal well-circumscribed area of increased density compared with adjacent normally enhancing splenic pulp, completely within the spleen and frequently accompanied by a halo of low-density hematoma, which disappears on late portal phase”, often corresponds to a pseudoaneurysm [2,4–8]. Although the beneficial role of angioembolization of splenic pseudoaneurysms is not yet unanimously recognized [9–11], most authors agree that embolization improves the success rate of NOM of splenic fractures [6,8,12–14].

It has been observed that between 38% and 74% of splenic pseudoaneurysms were only detected at control CT, performed between 24 and 72 h after admission [5,15,16]; such pseudoaneurysms are referred to as “latent” or “delayed” pseudoaneurysms. The advent of CES using second generation ultrasound contrast media recently has led practitioners to reexamine the value of sonography in blunt trauma patients, since CES now achieves sensitivities and specificities close to that of CT for the depiction of solid organ injuries [17,18]. Recent reports also showed that CES could depict intraparenchymal vascular injuries of the spleen [19–21]. However, no series evaluated whether this technique can be used for the systematic screening of post-traumatic splenic pseudoaneurysms.

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The objective of this study was to prospectively evaluate the capacity of CES to detect delayed posttraumatic splenic pseudoaneurysms on a consecutive series of patients with a grade 2 or higher splenic injury.

2. Methods

This prospective study was approved by the institutional review board (CER 04-207). A written informed consent was obtained from each patient before performing CES. The study was conducted over 7 years, from October 1, 2004 to September 30, 2011. Subjects enrolled in the study included all adults patients (>18 years old) admitted to our center after a blunt abdominal trauma, in whom a splenic injury of grade II or higher was depicted on admission CT examination, according to the American association for the surgery of trauma (AAST) classification [22].

Patients with a high grade splenic laceration (grade V) or active splenic bleeding on admission underwent immediate surgery, following our institution’s guidelines, in accordance to the AAST based Mirvis classification (blush of contrast media is an indication for angiography and embolization, while extravasation of contrast mandates surgery) [3]. Splenic lacerations (grade II or higher) without vascular injury depicted on admission CT underwent CES within 48–72 h after admission, for detection of vascular injuries. A control CT was obtained within 6 h after CES was performed. If a vascular injury was depicted on control CT, an angiographic examination was obtained within the next 12 h to confirm the diagnosis and, if confirmed, an embolization was performed. Patients with grade I splenic lacerations were not included because they are less prone to develop pseudoaneurysm and failure of NOM than higher grades [16,23,24].

Exclusion criteria were: pregnancy, absence of informed consent and death from a non–spleen related injury within 48 h after admission. Clinical and surgical follow-up were performed in every patient until the time of discharge, to determine the rate of successful NOM. If an abdominal CT was performed, for any clinical reason, in addition to the control CT, it was also analyzed for the presence of a splenic pseudoaneurysm, and referred to as “delayed CT”.

During the study period, a blunt splenic injury of grade II or higher was detected on admission CT in 116 adult patients. A high grade splenic laceration (grade V) or active splenic bleeding was found in 49 (42%) patients who underwent immediate surgery. Sixty-seven (58%) of the 116 patients were selected for NOM of the splenic injury.

65 of these 67 patients did not have a vascular injury on admission CT. Two of them were excluded from the study: one refused to participate in the study, the second was unconscious and thus unable to sign the informed consent. A control CES was performed within 48 and 72 h in the 63 remaining patients who formed our study population.

2.1. CT examinations

Admission abdominal CT images were acquired in the frame of a single-pass continuous whole-body protocol dedicated to polytrauma patients, consisting of a one sweep acquisition from the circle of Willis through the pubic symphysis, set up to obtain a mixed phase (both arterial and portal) on the liver and spleen. Whenever feasible, arms were positioned by the side of the head. From October 2004 to September 2010, CTs were performed on a 16-row Philips MX 8000 (Philips Medical Systems, Best, The Netherlands), using 16 mm × 1.5 mm collimation, pitch 1.35, gantry rotation period 0.5 s, tube potential 120 kV, tube charge per gantry rotation 180 mAs, reconstruction slice thickness 2.0 mm, 15 s after administration of a power-injected single bolus of 110 mL non-ionic intravenous contrast material (iomeprol 400 mgI/mL, iomeprum®, Bracco, Manno, Switzerland), at a flow rate of 4 mL/s.

Beginning October 2010, CT was performed on a 64-row Discovery 750 HD scanner (GE Healthcare, Cleveland), using 64 mm × 1.25 mm collimation, pitch 0.584 mm, gantry rotation period 0.7 s, tube potential 120 kV, tube charge 115 mA, reconstruction slice thickness 2.0 mm, after administration of a power-injected single bolus of 120 mL of iohexol 350 mgI/mL (Accupaque®, GE healthcare, Opfikon, Switzerland), at a flow rate of 4 mL/s. Scanning was automatically triggered, using a threshold of 100HU in the ascending aorta. Delayed images were obtained when a solid organ injury was detected on the initial series, to improve the detection rate of active bleeding.

Abdominal control CT was obtained using the same parameters as admission CT except scanning was performed on the spleen at both arterial and venous phases.

2.2. Ultrasonographic examinations

CES was performed by one of the two attending physicians on call for the emergency radiology unit, each with a prior experience of at least 100 CES abdominal examinations, using an Aloka SSD 5000 SV ultrasound device (2004 release), and a 3.5-MHz convex sector probe. The operator was aware of the patient’s admission CT result. An initial analysis of the spleen parenchyma was first performed on a standard B-mode imaging. Then the operator switched on the pulse inversion harmonic mode, with a reduced mechanical index of 0.18. Two and a half mL of a second-generation contrast agent (sulfur hexafluoride, SonoVue®, Bracco), were injected intravenously, using a 20-gauge catheter placed into an antecubital vein, followed by a 10-mL flush of saline water (0.9% NaCl). Serial images of the spleen were obtained every 3 s from the beginning of the injection, for a total duration of 3 min. A focal pooling of contrast medium during the arterial phase, with a similar enhancement as the splenic artery, surrounded by a normally enhancing or non-enhancing (injured) parenchyma, that can be retrieved after successive microbubble destructions (flushes) was considered positive for a vascular injury (pseudoaneurysm) [19,21]. The operator had to fill out a study form within 10 min after completion of the examination, for the presence of absence of a pooling of contrast suggestive of a pseudoaneurysm. It was not possible to report an examination as indeterminate.

2.3. Angiographic examination

Digital subtracted angiography examination was performed on a Siemens Axiom Artis angiographic device, using 100–200 mL of iohexol 270 mgI/mL (Accupaque®, GE healthcare, Opfikon, Switzerland). Anteroposterior and oblique projections of the spleen were obtained after catheterization of the main splenic artery with an adapted 5F catheter, and also after selective catheterization of the distal branches with a 2.7F microcatheter (Terumo, Leuven, Belgium). When splenic pseudoaneurysms were detected, selective embolizations were performed with either gelatin pledgets (Gelfoam, Pharmacia & Upjohn Company, Peapack, NJ) or 0.018 in. microcoils (Hilal, Cook Medical, Bloomington, IN).

3. Results

Of the 63 patients included in the series, 23 (37%) had a grade II splenic laceration, 24 (38%) a grade III, and 16 (25%) a grade IV, found at admission CT.
Fig. 1. Patients with blunt splenic trauma selected for non-operative management: detection of splenic vascular injuries consistent with a pseudoaneurysm at admission CT, at control contrast enhanced sonography (CES), at control CT (performed 48–72 h after admission) and at delayed CT (performed later than 72 h after admission).

<table>
<thead>
<tr>
<th>No Pseudoaneurysm at CES n=57</th>
<th>Pseudoaneurysm at CES n=6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pseudoaneurysm at control CT n=55</td>
<td>Pseudoaneurysm at control CT n=8</td>
</tr>
<tr>
<td>No further abdominal CT n=34</td>
<td>Delayed abdominal CT n=21</td>
</tr>
<tr>
<td>No Pseudoaneurysm at delayed CT n= 17</td>
<td>Pseudoaneurysm at delayed CT n= 4</td>
</tr>
</tbody>
</table>

Table 1
Imaging characteristics and treatment of patients in whom a pseudoaneurysm was found at control CT (reference standard).

<table>
<thead>
<tr>
<th>Case</th>
<th>Splenic laceration CT-grade</th>
<th>Blush of contrast at CES</th>
<th>PSA size at CT (mm)</th>
<th>PSA at arteriography</th>
<th>Embolization</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IV</td>
<td>+</td>
<td>19</td>
<td>NO^a</td>
<td>Surgery</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>III</td>
<td>+</td>
<td>15</td>
<td>−</td>
<td>NOM</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>III</td>
<td>+</td>
<td>9</td>
<td>+</td>
<td>NO^c</td>
<td>NOM</td>
</tr>
<tr>
<td>4</td>
<td>IV</td>
<td>+</td>
<td>11</td>
<td>+</td>
<td>NORM</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>III</td>
<td>−</td>
<td>10</td>
<td>+</td>
<td>NORM</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>III</td>
<td>−</td>
<td>6</td>
<td>NO^f</td>
<td>NORM</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>II</td>
<td>+</td>
<td>9</td>
<td>+</td>
<td>NORM</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>IV</td>
<td>+</td>
<td>4, 8^d</td>
<td>+</td>
<td>NORM</td>
<td></td>
</tr>
</tbody>
</table>

CES, contrast enhanced sonography PSA; pseudoaneurysm; NO, not obtained; NORM, non-operative management; (+), positive examination; (−), negative examination.

^a Patient underwent splenectomy before angiography could be performed.
^b Embolization could not be achieved because of tortuous vessels.
^c Patient did refuse angiography.
^d 2 pseudoaneurysms were detected in this patient.

3.1. CES and control CT (Fig. 1)

CES was reported positive for a pseudoaneurysm in 6 (9%) of the 63 patients (Fig. 2). No major or minor complications resulted from the injection of sonographic contrast media. Control CT was obtained in all 63 patients, within 6 h after CES. Vascular injuries, consistent with pseudoaneurysms, were detected in 8 (13%) patients by CT (Table 1): one with a grade II splenic laceration, 4 with a grade III, and 3 with a grade IV. Thus, 2 CES were considered false negative, when compared to CT (Fig. 3). There were no false positive CES. The sensitivity, specificity, negative and positive predictive value of CES to depict vascular injuries are shown in Table 2.

3.2. Delayed CT

Delayed CT was required by the surgeon or the intensive care unit physician between 4 and 6 days after admission CT was performed for 21 patients, in whom both CES and control CT were reported negative for a suspicion of pseudoaneurysm. A vascular injury, consistent with pseudoaneurysm was found in 4 (19%) of these 21 patients (Fig. 4).

3.3. Angiographic examinations

An angiographic examination was performed within 12 h after control CT in 6 of the 8 patients in whom CES or control CT were suggestive of delayed vascular injury, 4 of them underwent embolization (Table 1).

An angiography with embolization was performed in the 4 patients in whom a vascular lesion was only suspected on a delayed CT.

Table 2
Diagnostic test results for the depiction of delayed splenic traumatic pseudoaneurysms at contrast enhanced sonography with regard to CT findings (reference standard).

<table>
<thead>
<tr>
<th>Statistical measure</th>
<th>CES^a</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity</td>
<td>100 (55/55)</td>
<td>92–100</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>75 (6/8)</td>
<td>40–93</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>100 (6/6)</td>
<td>56–100</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>96 (55/57)</td>
<td>87–100</td>
</tr>
</tbody>
</table>

CES, contrast enhanced sonography; CI, confidence interval.

^a The first number corresponds to percentage. Numbers in parentheses are absolute numbers of cases.
3.4. Clinical follow-up and failure of NOM

Of the 63 patients included in the study, 5 (8%) eventually required splenectomy between 2 and 12 days after trauma due to active bleeding. Only one of these 5 patients, the aforementioned 18-year-old man, had a vascular injury consistent with a pseudoaneurysm, which was depicted at both CES and CT.

4. Discussion

The objective of the study was to evaluate CES for the detection of delayed pseudoaneurysms in blunt splenic trauma patients. In the current series, 4 (3.5%) vascular injuries suggestive of pseudoaneurysms were detected on admission CT in 116 blunt abdominal trauma patients, while 8 others were detected at control CT performed within 72 h after admission. These results substantiate the observation reported by Davis et al. [5] that up to 76% of pseudoaneurysms are only detected some days after admission.
Many studies report the high sensitivity and specificity of CES for depiction of abdominal traumatic solid organ injuries [17,18,25], which is comparable to that of CT. However, very few studies address the potential of CES for the detection of traumatic vascular injuries, including pseudoaneurysms [19–21]. None of the research systematically compared this technique on a consecutive series of blunt splenic trauma patients, with CT or angiography as the reference standard. In our study, CES achieved a high positive and negative predictive value for depiction of delayed pooling of contrast, suggestive of pseudoaneurysms, when compared to CT. Our results suggest that a positive CES is sufficient to warrant an angiography without need of control CT. A negative CES, however, does not completely rule out a pseudoaneurysm.

A control CT has been advocated by some authors for depiction of latent pseudoaneurysms [5,16,26]. Nevertheless, a survey revealed that only 14.5% of the respondents followed this recommendation in routine practice [23]. This may be due to the fact that obtaining a control CT in a multitrauma patient is not an easy task and requires the mobilization of numerous medical resources. Besides, the percentage of pseudoaneurysms detected at control CT, performed 24–48 h after admission, is relatively low [5,15,16] and the natural progression of delayed pseudoaneurysms is still unclear [9,16]. Thus, many trauma associations and authors do not yet consider it appropriate to recommend systematic delayed CT in their guidelines [23,27]. In this setting, in spite of a limited sensitivity, CES may constitute a viable alternative to CT for the screening of delayed pseudoaneurysms in blunt splenic trauma patients because it is safe and easily performed at the patient’s bedside [28].

An ancillary but relevant finding of the current study is the incidental depiction of a splenic blush of contrast in 4 (19%) of 21 patients who underwent a delayed CT, 4 days or later (up to 12 days) after admission. Arteriography confirmed that all 4 cases were pseudoaneurysms. None of these were detected at admission CT or at subsequent CES and control CT performed within 3 days after admission. This observation suggests that a significant number of pseudoaneurysms may only be detected beyond 3 days after admission. In the current study, only one patient who failed NOM had a pseudoaneurysm detected at control imaging. It is possible that most failures of NOM may be attributed to pseudoaneurysms that manifest after control CT is performed and thus remain undetected. This may explain that no failure of NOM was observed among patients who underwent embolization of a pseudoaneurysm. It can therefore be speculated that the rate of successful NOM in splenic trauma patients may be improved if the screening for pseudoaneurysms was not limited to 3 days after admission. It is unrealistic to recommend serial control CT in routine practice since most of the
centers do not even perform one, as mentioned above. CES, however, may be easily used to obtain serial follow-up imaging in blunt splenic trauma patients and thus to select patients for angiography. Obtaining serial CES in the monitoring of spleen trauma, for instance at days 2 and 4 after admission, could not only improve the detection rate of delayed pseudoaneurysms, but also allow a better understanding of the natural progression of these pseudoaneurysms. This may help improve the outcome of NOM in blunt splenic trauma patients.

There are some limitations to our study. In our methodology, the sonologist was required to assess the presence or absence of pseudoaneurysms immediately after completion of the examination, without the possibility of classifying the result as indeterminate. Since the quality of CES examinations was not evaluated in this study, it is possible that technical problems, such as the presence of skin wounds, thoracic drains and painful rib fractures may constitute a limitation of this imaging method. Furthermore, the small number of cases in our series did not allow us to analyze whether the size of pseudoaneurysms is related to false negative CES. Indeed, only 2 pseudoaneurysms (of 6 mm and 10 mm, respectively) were missed at CES, when compared to CT, which is not sufficient to draw any conclusion about the minimal critical size a pseudoaneurysm should reach before being depicted by CES. Another limitation of the study is that CT and not angiography has been considered the reference standard to assess the value of CES for depiction of delayed pseudoaneurysms. Indeed, it would have been practically impossible in our institution, like in most other hospitals, to require a systematic delayed angiographic examination in every patient included in this survey. The limitation of CT for detection of pseudoaneurysm has been reported by many authors, when compared to angiography, which is unanimously recognized as the reference standard for depiction of pseudoaneurysms [5,7,12,13,29,30]. In our series, one suspicion of pseudoaneurysm at both CES and control CT was not confirmed at subsequent angiography. It is

![Fig. 4. 27 year-old man admitted after a fall. (a) Admission axial CT image shows a grade 3 splenic laceration (arrowhead). (b) Contrast enhanced sonographic examination (late arterial phase), performed 2 days after admission, shows a hypoechoic unenhancing area (arrowhead) in the center of the spleen. No pooling of contrast suggestive of a pseudoaneurysm was reported by the sonologist. (c) Control CT axial image, shows the hypodense injury within the spleen (arrows), without evidence of vascular lesion. (d) Delayed CT axial image obtained 5 days after admission, because patient developed abdominal pain. A pooling of contrast media is clearly visible in the periphery of the injury (arrow). (e) Angiographic examination performed after delayed CT confirms the presence of the pseudoaneurysm (arrow), which was embolized. The patient underwent a successful non-operative management.](image)
impossible to assess whether this case corresponded to a false negative CT for pseudoaneurysm or if the lesion resolved by itself, during the time elapsed from control CT to angiography, as already reported in the literature.

Last, the study was performed over 7 years, using the same ultrasound equipment. It is then not excluded that the sensitivity for depiction of pseudoaneurysms might now be better, by the improvement in the ultrasound technologies.

In conclusion, the current study showed that CES may be used for the screening of delayed pseudoaneurysms in blunt splenic trauma patients. It also suggested that many pseudoaneurysms may only be depicted on very remote CT examinations, performed 4 days or later after admission. Thus, it can be speculated that the outcome of NOM could still be improved by performing serial CES screenings, at days 2 and 4 after admission. Further studies are needed to substantiate our findings.

Conflict of interest statement

None declared.

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