Efficacy of Emergent Splenic Artery Embolization in Conservative Treatment of High Grade Splenic Injury

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Splenic salvage after trauma has been attempted to avoid lifelong risk for increased susceptibility to infection after splenectomy. Splenic artery embolization (SAE) for patients with blunt splenic injury has been applied in the protocols of splenic salvage. The purpose of this study was to evaluate the efficacy of emergent splenic artery embolization for patients with grade III or higher grades of blunt splenic injury.

From January 2001 to January 2003, 62 adult patients with blunt splenic injuries were included in this study (excluding patients with multiple trauma or those who died of severe trauma within 48 hours after admission). CT scan was performed for grading of the splenic injury and detecting other visceral injury. SAE with coils and gelfoam was performed on patients who were grade III, IV, or V splenic injury to avoid unnecessary surgical intervention.

Eleven of the 62 patients underwent SAE (5 grade III, 5 grade IV and 1 grade V). SAE without surgical intervention was successful in 9 (82%) patients. Transient hemostasis was obtained in the other two of these 11 patients (1 grade III and 1 grade V). Surgical splenectomy had to be performed in treating re-bleeding in these two patients. Only one of our patients developed splenic abscess.

Using SAE with coils and gelfoam as a nonsurgical treatment of patients with blunt splenic injury can preserve splenic function and avoid the risk of surgical intervention. Success rate was good in selected cases.

Key words: Arteries, therapeutic embolism; Spleen, injuries

Splenectomy is a traditional treatment for splenic injury. Recently, splenic salvage after trauma has been attempted to avoid lifelong risk for increased susceptibility to infection after splenectomy. Splenic artery embolization (SAE) for patients with blunt splenic injury has been applied in the protocols of splenic salvage [1, 2]. SAE can both avoid the risk of surgical intervention and preserve the splenic function. However, the indications for SAE remained controversial. In our hospital, transcatheter arterial embolization of the splenic artery was performed in patients with blunt splenic injury to preserve splenic function and avoid unnecessary operation. The purpose of this study was to evaluate the efficacy of emergent SAE for patients with grade III or higher grades of blunt splenic injury.

MATERIALS AND METHODS

Patient Population and Methods

From January 2001 to January 2003, 88 adult patients with blunt splenic injuries were evaluated in our hospital. All of the patients with blunt splenic injury were prospectively evaluated with the intent of avoiding unnecessary operation and preserving splenic function. After initial evaluation and fluid resuscitation, patients who were hemodynamically unstable underwent emergent operation immediately.

All patients who were transiently hemodynamically stable, with or without fluid resuscitation, underwent CT imaging of the abdomen and pelvis for grading the splenic injury and detecting other visceral...
injury (Fig. 1). Twenty-six patients were excluded from this study because they had multiple organs injury requiring emergency surgery (e.g., pancreatic injury, severe liver laceration, or bowel perforation) or died of severe multiple traumas within 48 hours after admission. We graded the severity of splenic injury according to the classification of the American Association for the Surgery of Trauma (AAST).

After CT examination, the trauma surgeons consulted us for the evaluation of transcatheter splenic artery embolization (SAE). Emergent SAE was performed immediately on patients who had grade III, IV, or V splenic injury combined with blood pressure drop off.

<table>
<thead>
<tr>
<th>Injury grade</th>
<th>No. of patients</th>
<th>No. of successful SAE</th>
<th>Success rate</th>
<th>Post-SAE abscess formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>5</td>
<td>4</td>
<td>80%</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>5</td>
<td>5</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>9</td>
<td>82%</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 1. Images of blunt splenic injury in one of our patients (a) CT (contrast medium-enhanced) image shows splenic injury with marked hemoperitoneum. Rupture of intraparenchymal hematoma with active bleeding (grade IV splenic injury) was noted. (b) Angiographic picture of the patient shows contrast medium extravasation within splenic parenchyma (arrow). (c) Splenic arteriogram after embolization of the patient shows occlusion of injured branches (arrow) without collateral circulation formation and preserving the unhurt branches (arrow head).
The vital signs of the patients after SAE were observed closely in the ICU. If SAE turned out to be ineffective (recurrent bleeding, progressive abdominal distention or hemoglobin level drop-off), emergent laparotomy was performed as salvage.

All patients who underwent successful SAE had a follow-up abdominal sonography in one week and CT scan in one month. Besides the above examinations, we evaluated their splenic function by peripheral blood smears on days 7 and 30, and Tc-99m RBC scan on day 30.

**Imaging Technique**

CT studies were performed with a Siemens multi-detector helical CT scanner. The abdominal and pelvic CT scan of all trauma patients was studied at 5-mm intervals with a 60-second delay after intravenous administration of 80 ml of contrast medium at a rate of 3mL/sec.

All angiographies were performed through a puncture at the right femoral artery. All patients underwent celiac arteriogram using a 4 Fr catheter to evaluate the splenic artery, its branches and severity of vascular injury (Fig. 1). The catheter (or micro-catheter) was then placed proximal to the injured branch or branches of the splenic artery. Embolization was performed using “Infusion of 1 × 1 mm gelfoam cubes” or “3 × 5 - 3 × 4 mm steel coils” (Cook, Bloomington, IN, USA) or “2 × 6 - 2 × 5 mm micro-coils” via flow guidance until blood flow of the injured branch of splenic artery was almost completely impeded. Splenic arteriogram after embolization was performed to confirm the occlusion of injured branches, no obvious collateral circulation formation and the preservation of uninjured branches (Fig. 1).

**RESULTS**

Eleven patients (9 males, 2 females) who were 21-63 years old (mean age, 39.3 ± 14.88) underwent SAE. When admitted to our hospital, all of the 11 patients had marked hemoperitoneum on CT scan and had unstable vital sign before fluid resuscitation. However, they became transiently and hemodynamically stable after resuscitation. The severity grades (according to AAST classification) of the patients who underwent SAE are shown in Table 1. There were 5 patients with grade III, 5 patients with grade IV and 1 patient with grade V splenic injury.

Delayed splenic rupture in patients with blunt splenic injury was noted in two of our patients (patients 7 & 10 in Table 2). Patient 7 was upgraded to grade IV splenic injury from grade I on day 37. Patient 10 was upgraded to grade IV splenic injury from grade II on day 3. Both of them were treated successfully with splenic artery embolization.

One patient developed traumatic pseudoaneurysm of the intraparenchymal splenic artery after blunt splenic injury. The patient was treated with SAE successfully (Fig. 2).

Transcatheter arterial embolization was successful in 9 of these 11 patients. Two patients who underwent SAE needed surgical intervention due to persistent bleeding after SAE (Table 1). One patient (patient 1) developed splenic abscess on day 16 after SAE. After percutaneous transsplenic abscess drainage, he was discharged uneventfully. All the 9 patients were hemodynamically stable after embolization and discharged from our hospital smoothly. All the 9 patients recovered well and preserved their splenic function without other complication in the period (1.5 months) of follow-up.

We used emergent SAE to avoid unnecessary surgery intervention. Our successful rate was 82% (9/11). Also, the average time we spent on SAE (from patients getting on the angiographic table to patients getting off the table) was 58 +/- 13.97 minutes.

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**Table 2. List of patients who underwent SAE**

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age(Y/O)</th>
<th>Gender</th>
<th>Injury grade</th>
<th>Embolizer</th>
<th>Post-SAE OP</th>
<th>Follow Up</th>
<th>Delay bleeding</th>
<th>Pseudoaneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>M</td>
<td>IV</td>
<td>coils</td>
<td>--</td>
<td>Splenic abscess</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>M</td>
<td>III</td>
<td>coils</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>M</td>
<td>IV</td>
<td>Coils + gel*</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>58</td>
<td>F</td>
<td>III</td>
<td>gel</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>39</td>
<td>M</td>
<td>III</td>
<td>gel</td>
<td>+</td>
<td>OP on day 3</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>61</td>
<td>F</td>
<td>III</td>
<td>coils</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>29</td>
<td>M</td>
<td>IV</td>
<td>Microcoils + gel</td>
<td>--</td>
<td>O.K</td>
<td>+, day 37</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
<td>48</td>
<td>M</td>
<td>IV</td>
<td>coils</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>9</td>
<td>63</td>
<td>M</td>
<td>V</td>
<td>microcoils</td>
<td>+</td>
<td>Op on day 2</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>33</td>
<td>M</td>
<td>IV</td>
<td>coils</td>
<td>--</td>
<td>O.K</td>
<td>+, day 3</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>24</td>
<td>M</td>
<td>III</td>
<td>coils</td>
<td>--</td>
<td>O.K</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Note:---gel* = gelfoam; --: no; +: yes; O.K: uneventful course after discharge
DISCUSSION

Traditionally, splenorrhaphy and splenectomy were the generally accepted methods of treatment for blunt splenic injury in adult patients. However, splenectomy will increase the risk of post-splenectomy infection [3, 4]. Patient undergoing surgical intervention take the risks of anesthesia and operation. Transarterial embolization in treatment of visceral vascular bleeding was successfully applied in traumatic injury for a long time. The technique of splenic artery embolization is easy, but there is no consensus on the role of SAE as an adjuvant method to the nonoperative treatment of splenic injury. In our hospital, we used SAE to increase the success rate of nonoperative management.

Recently, some studies reported that only grade of splenic injury, not patient’s age, increases the risk of nonoperative management failure [5], and vascular injury increases with splenic injury grade [6]. Therefore, it was only the grade of splenic injury, not patient’s age, mainly considered in deciding whether to perform splenic artery embolization in our study. One patient with grade V splenic injury was failed in conservative treatment after SAE. Due to only one case in our series, we cannot evaluate whether SAE is suitable for this highest grade of splenic injury. We need more experience to evaluate the efficacy of SAE in grade V splenic injury. Excluding Grade V splenic injury, the success rate of SAE for Grade III & IV blunt splenic injury was 90% (9/10).

Figure 2. images of traumatic pseudoaneurysm in one of our patients (a) CT (contrast medium-enhanced) image shows a well-circumscribed lesion with collection of contrast medium in splenic parenchyma (arrow). (b) Angiographic picture of the patient shows one intraparenchymal splenic pseudoaneurysm (arrow). (c) Splenic arteriogram after embolization of the patient shows occlusion of injured branches (arrow) without collateral circulation formation and preserving the unhurt branches (arrow head).
Two of our patients who underwent SAE needed further surgical intervention. One patient (patient 9) had a grade V splenic injury. His angiographic study revealed extravasation of contrast medium beyond the splenic parenchyma. Microcoils were packed into the injured branches of splenic artery followed by infusion of small gelfoam cubes. Celiac trunk angiogram after embolization showed occlusion of the injured branches without other collateral circulation formation. The patient underwent splenectomy on the next day after embolization due to persistent distention of the abdomen with dyspnea. The other patient (patient 5) who underwent surgical intervention had a grade III splenic injury, and his angiographic study revealed interruption of small branches of segmental splenic artery and loss of the splenic parenchyma stain without extravasation of contrast medium. SAE was performed with infusion of gelfoam cubes only. Celiac trunk angiogram after embolization showed good result, too. The patient underwent splenectomy on day 3 after embolization due to progressive hemoglobin level drop off. We could not find the definite reasons why SAE ended up failure in the two patients when we reviewed the angiographic pictures of the two patients again and again.

Haan et al. [6] reported that embolization improved nonoperative salvage rates even with high-grade injury. However, repeat angiography was performed for suspicion of bleeding in 10% of their patients. Repeat angiography was not performed in our study. If we performed repeat angiography, we believe that we would improve our success rate.

Currently, nonoperative management by means of observation and bed rest is commonly practiced in hemodynamically stable patients with blunt splenic injury [7]. Among our patients, one patient (patient 8) was recognized to have a splenic artery pseudoaneurysm (Fig. 2). The patient was treated well with superselective SAE without other sequelae (Fig. 2). Salis et al. [8] reported that traumatic intrasplenic arteriovenous fistula could be treated with superselective embolization. Formation of post-traumatic pseudoaneurysm has been identified as a predictor of failure of conservative treatment. Embolization of post-traumatic splenic artery pseudoaneurysm improved the rate of successful nonoperative management of blunt splenic trauma [1].

Delayed splenic rupture, though relatively uncommon, is a recognised clinical entity. It is characterized by an asymptomatic period of at least 48 hours between the time of injury and the appearance of signs of internal hemorrhage [9-11]. The significance of delayed rupture lies in the relatively high mortality rate, compared with that associated with acute splenic rupture [12]. The pathophysiology behind delayed splenic rupture is still not fully understood. One widely accepted theory suggests that formation of a subcapsular haematoma at the time of injury followed by development of increasing tension within it, results in subsequent rupture through the capsule, intraperitoneal bleeding and pain [13, 14]. Delayed splenic rupture in patients with blunt splenic injury was noted in two of our patients (one on day 3 and the other on day 37). Both of them were treated successfully with splenic artery embolization. Therefore, patients who fail treatment by means of observation and bed rest can also be treated well with emergent transcatheter splenic artery embolization. Surgical intervention is not the only way to treat delayed splenic rupture.

One of the 9 patients who underwent successful embolization developed splenic abscess on day 16 after SAE. The patient also had severe head injury and underwent emergent craniotomy with long-term hospitalization. Splenic abscess was treated with percutaneous trans-splenic abscess drainage [15-17]. Splenic infarcts are common after splenic artery embolization. Superselective transcatheter embolization (distal embolization) is more likely to produce infarcts than the main (proximal) splenic artery embolization, but they seem to resolve without sequelae in the majority of patients [18]. Gas may be present within an infarct after embolization with gelfoam; however, the presence of air/fluid level is a better predictor of splenic abscess [18]. Splenic abscess formation after transcatheter splenic artery embolization can be treated well with percutaneous trans-splenic abscess drainage [15-17] and need no surgery intervention. Therefore, splenic abscess formation does not decrease the success rate of nonoperative management.

Hagiwara et al. reported that evaluation and use of angiography for splenic injury and the subsequent management got good success rate for nonsurgical management of patients with blunt splenic injury [2]. They also reported that some of their patients may have undergone unnecessary embolization to achieve a low frequency for laparotomy. Scalfani et al. [19] reported that transcatheter arterial embolization results in salvage of splenic function in patients with angiographic evidence of contrast medium extravasation. We tried to create a protocol that could be used to select patients suitable for splenic artery embolization and to avoid unnecessary angiography or surgery intervention. Through our experience of SAE for patients with blunt splenic injury, we suggest the indications for transcatheter SAE as: 1. contrast medium extravasation on CT scan; 2. pseudoaneurysm or A-V
fistula formation; 3. marked hemoperitoneum on CT scan with unstable vital sign before fluid resuscitation; 4. failure of conservative treatment such as delayed bleeding; and 5. grade III, IV or V splenic injury.

CONCLUSIONS

Using transcatheter arterial embolization of the splenic artery with coils or microcoils followed by gelfoam as a nonsurgical treatment of patients with blunt splenic injury can preserve splenic function and avoid the risk of surgical intervention. On the basis of our experience, the success rate of SAE for grades III and IV blunt splenic injury was 90% (9/10). The complication rate of SAE was low, and complications could be treated without surgical intervention.

REFERENCES

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以緊急脾動脈栓塞作爲高度脾外傷的保守治療之效果評估

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為避免脾臟切除後增加感染率，脾外傷時會盡力去保留脾臟，以脾動脈栓塞治療脾臟鈍傷已經被使用來保留脾臟，這個研究的目的是要評估以緊急脾動脈栓塞治療三度以上脾鈍傷的效力。

從2001年1月到2003年1月，共有62位脾臟鈍傷的成人（排除多器官外傷及到院後48小時內死亡的嚴重外傷），以電腦斷層掃描評估脾臟受傷的嚴重度及檢測其他器官的傷害情況，為了避免不必要的開刀，我們用 coils 及 gelfoam 來處理三度以上脾鈍傷的脾動脈栓塞。

在62位病人中有11位接受脾動脈栓塞（其中有5位三度，5位四度及1位五度脾鈍傷），11位中有9位病患（82%）在脾動脈栓塞後成功的避免開刀，另外2位病人（1位三度及1位五度脾外傷）只能暫時的止血，最後以手術摘除脾臟來治療栓塞後的再出血，11位病人中只有1位在栓塞後引發脾膿瘍。

我們發現用 coils 及 gelfoam 來栓塞脾臟鈍傷後的脾動脈可以保留脾臟功能而且避免手術的風險，在篩選過的病例中成功率很高。

關鍵詞：脾動脈栓塞術；脾臟；外傷