Angiographic Embolotherapy is An Effective Treatment for Blunt Splenic Injuries with Active Hemorrhage or Transient Response to Fluid Resuscitation

Patients of blunt splenic injuries who had CT findings of active hemorrhage or transient response to fluid resuscitation were referred for angiographic embolotherapy. The purpose of this retrospective study was to determine the effectiveness, complications, and final outcome of different types of embolotherapy.

The charts of 30 consecutive adult patients who received spleen embolotherapy from January 2001 to December 2004 were reviewed. One patient of multiple trauma died during embolotherapy was excluded. Of the remaining 29 patients, 9 (31.0%) underwent superselective branch-artery alone embolotherapy, 17 (58.6%) main-artery alone embolotherapy, 3 (10.4%) both branch- and main-artery embolotherapy. A continuous drop of hemoglobin occurred in 2 (6.9%) patients. Splenic abscess developed in 2 (6.9%) patients. None of the 29 patients died of spleen-related hemorrhage. For patients accepted branch-artery alone embolotherapy, the odds ratios of having a post-embolotherapy event were 2.00 (95% CI: 0.11, 36.31), when compared with patients accepted main-artery alone embolotherapy. The ratios were all 2.38 (95% CI: 0.13, 42.83) for patients with branch-artery alone embolotherapy, when compared with patients who were not treated with branch-artery embolotherapy alone.

In conclusion, the association between risk factors (effectiveness, complications, outcomes) and types of embolotherapy had no statistical significance, however, it seemed that people who accepted branch-artery alone embolotherapy had a higher risk of complications than people accepted main-artery embolotherapy.

Spleen is the most commonly injured organ in blunt abdominal trauma (BAT) [1]. If splenic injury with ongoing hemorrhage is the cause of unstable hemodynamic condition in a patient of BAT, a timely intervention is warranted [1-6]. A delay in treatment will result in high mortality or morbidity [3, 7, 8]. In the past, splenectomy or splenorrhaphy has been the choice of surgical treatment for unstable patients [6, 9, 10].

An alternative spleen preserving intervention that is less invasive than that of splenorrhaphy is embolotherapy [6, 9-13]. The transcatheter arterial embolization (TAE) of the spleen is an angiographic method for arresting an ongoing hemorrhage by delivering embolic agents to the bleeder via a catheter. Spleen TAE has been reported as an effective treatment for blunt splenic injuries in some Level I trauma centers in North America and Japan [7, 9-12, 14, 15]. In Taiwan, however, splenectomy is still commonly practiced in many institutions. It is partly because of the surgeons’ preference [7, 10, 16], and the other important reason is the lack of readiness of radiology staff in the emergency settings.

In the past five years, we have encountered a continuous increase of referrals of BAT patients...
from trauma surgeons for spleen TAE. Therefore, in this series, our purposes are to determine the types and effectiveness of spleen TAE, as well as the TAE complications and final outcome of patients.

**MATERIALS AND METHODS**

Within a 4-year study period from January 2001 to December 2004, 30 consecutive adult patients of blunt splenic injuries who had been treated with spleen TAE were registered in our radiology database. There were 28 men and 2 women, with a mean age of 35.2 ± 17.2 years (ranged from 18 years to 79 years). All of these patients were resuscitated according to advanced trauma life support protocol on arrival at our emergency department before they were sent to angiography suite. Among them, 3 patients had multiple organ injuries that required multiple sites of TAE (spleen and liver; spleen and pelvis; spleen, kidney, and pelvis in every one patient respectively). There were 31 spleen TAE procedures in 30 patients. Ten procedures were done because CT showed contrast material extravasation from the spleen. Sixteen procedures were done because the response to fluid resuscitation was transient. Another 5 procedures were performed selectively because of a continuous drop of hemoglobin at wards. The selection of embolic agents was at the discretion of each radiologist. Of 31 procedures, 22 used coils, 6 used coils followed by pieces of gel-foam, 3 used gelfoam particles only.

Their medical records were retrospectively reviewed for the (1) types of spleen TAE (branch-artery alone TAE, main-artery alone TAE, both branch- and main-artery TAE), (2) success or failure of TAE (successful TAE was defined as cessation of contrast material extravasation or occlusion of the targeted vessels on post-TAE angiography), (3) effectiveness of TAE (effective TAE was defined as hemodynamic and hemoglobin level stabilization at serial post-TAE examinations), (4) complications, and (5) final outcome of the patients.

The association between risk factors (effectiveness, complications, and outcomes) and different types of spleen TAE were compared by using univariate logistic regression (SPSS 15.0 SPSS Inc., Chicago, IL). The odds ratio, 95% confidence intervals, and p-value were computed. In order to compute the ratio of 2 odds, we compared the occurrence of events (1) between branch-artery alone group and main-artery alone group, (2) between branch-artery alone group and non branch-artery alone group, and (3) between main-artery alone group and non main-artery alone group. A p-value of less than 0.05 was considered statistically significant.

**RESULTS**

Among the 30 patients treated with spleen TAE, a 42 year-old woman of multiple trauma that involved the central nervous system, maxillofacial bones, lung, spleen and kidney, as well as pelvis died of cardiopulmonary failure during the procedure despite aggressive cardiopulmonary resuscitation. This patient was excluded from the following analysis (Table 1). Of the remaining 29 patients, 9 (31.0%) received branch-artery alone TAE (Figure 1A, 1B, 1C), 17 (58.6%) received main-artery alone TAE (Figure 2A, 2B), 3 (10.4%) received both branch-artery and main-artery TAE.

All spleen TAE procedures in these 29 patients were angiographically successful for arresting splenic hemorrhage. Although the hemodynamic condition of the 29 patients was stable after the ini-

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**Table 1. The effectiveness, complications, and outcomes of patients treated with different types of spleen TAE.**

<table>
<thead>
<tr>
<th>Analyzed items</th>
<th>Types of spleen TAE</th>
<th>Total (%)</th>
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<tbody>
<tr>
<td></td>
<td>Branch artery (N=9)</td>
<td>Main artery (N=17)</td>
</tr>
<tr>
<td>Drop of hemoglobin after initial TAE</td>
<td>1 (11.1%)</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Repeat TAE or spleen-related surgery</td>
<td>1 (11.1%)</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Spleen abscess after TAE</td>
<td>1 (11.1%)</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Mortality related to splenic hemorrhage</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
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</table>
Embolotherapy of blunt splenic injuries

Initial successful TAE, 2 (6.9%) patients suffered from a continuous drop of hemoglobin level after admission. Therefore, the overall effectiveness of initial spleen TAE was 93.1%.

**Figure 1.** A 18 year-old man with blunt abdominal trauma. a. Contrast-enhanced CT shows spleen injury with active bleeding (arrow). b. Angiography shows active arterial bleeders at lower pole of the spleen (arrow). Note that the celiac orifice is occluded and the splenic artery and other branches of celiac artery are reconstituted by pancreatoo-duodenal arcade at superior mesenteric arteriography. c. Angiography after spleen TAE at branch artery with coils and gelfoam pieces shows cessation of active splenic bleeding. The lower pole hypovascularity is consistent with post-TAE ischemia (arrow).

**Figure 2.** A 25 year-old man with blunt abdominal trauma. Contrast-enhanced CT shows spleen injury with active perisplenic bleeding (not shown). (A) Angiography shows active arterial bleeder (arrow) at the lower pole of spleen. (B) Angiography after spleen TAE at main splenic artery with coils (arrow) shows cessation of active bleeding. Note that the spleen perfusion is preserved through patent hilar vessels.
Embolo therapy of blunt splenic injuries

Table 2. Results of univariate logistic regression for types of spleen TAE1,2

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% Confidence interval</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Drop of hemoglobin after initial TAE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>B vs M</td>
<td>2.00</td>
<td>(0.11, 36.31)</td>
<td>0.639</td>
</tr>
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<td>B vs Non-B</td>
<td>2.38</td>
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<td>0.558</td>
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<td>M vs Non-M</td>
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1 Odd ratio for group “B+M” could not be estimated, because there was no case or no control in the group.
2 B and M were the abbreviators of branch-artery alone TAE and main-artery alone TAE respectively.

Of 9 branch-artery alone TAE patients, 8 (88.9%) were effective, 1 (11.1%) suffered from a drop of hemoglobin and then received splenectomy. Of 17 main-artery alone TAE patients, 16 (94.1%) were effective, a repeat TAE was performed for one patient (5.9%) who had a drop of hemoglobin and was subsequently effective in hemostasis. Of 3 patients with TAE at both branch-artery and main-artery, all (100%) procedures were effective.

Spleenic abscess developed in 2 (6.9%) patients, one of whom had been embolized with gelfoam at branch artery alone, and the other with coils at main artery alone. These abscesses were adequately drained by percutaneous catheter and patients were discharged uneventfully. None of the 29 patients died of spleen-related hemorrhage. One 79 year-old man died of pneumonia, sepsis, and multiple organ failure on day 22.

The results of univariate logistic regression are shown in Table 2. Odds ratio for the group that received both branch-artery and main artery TAE could not be estimated, because there was no case or no control in the group. For patients accepted branch-artery alone TAE, the odds ratio of having a drop of hemoglobin, repeated TAE or spleen-related surgery and splenic abscess were all 2.00 (95% CI: 0.11, 36.31), when compared with patients accepted main-artery alone TAE. For patients with branch-artery alone TAE, the ratios were all 2.38 (95% CI: 0.13, 42.83), when compared with patients who did not accept branch-artery alone TAE. For patients accepted main-artery alone TAE, the ratios were all 0.69 (95% CI: 0.04, 12.20), when compared with patients who did not accept main-artery alone TAE.

Although, the association between the risk factors and the types of spleen TAE was non-significant, it seemed that people who accepted branch-artery alone TAE had a higher risk of complications than people accepted main-artery alone TAE and people accepted both branch and main-artery TAE.

**DISCUSSION**

The objectives of spleen TAE in blunt splenic injuries are to arrest injury-related splenic hemorrhage, or to obliterate pseudoaneurysms and traumatic arterio-venous fistula [11]. We can achieve the objectives by decreasing the blood flow at main splenic artery so that a clot formation at the more distal bleeder can take place, or by directly clogging the injured arteries [11]. Deployment of coils at the main splenic artery is a preferred method to decrease blood flow to the spleen [10]. The collaterals from the short gastric artery can maintain the necessary spleen perfusion but the pressure of collateral flow is not high enough to cause rebleeding. Therefore, TAE at main splenic artery is a spleen preserving treatment and has been reported as a safe method. It occasionally leads to negligible peripheral small infarcts [10-12, 14, 15, 17].

Superselective TAE at a branch artery is a method to directly clog a bleeder by either coil deployment or injection of particles. The hemostasis can be more effectively achieved by branch-artery embolotherapy than by waiting for a formation of clot as in main-artery embolotherapy. However, this procedure usually takes a longer time to accomplish and requires more expertise in angiographic technique than those of main-artery embolotherapy [11, 12, 15]. Furthermore, splenic infarct within the territory of that branch artery is usually more complete because of inadequate collaterals [15]. Occasionally, technical failure may occur if the artery is tortuous, and this time consuming procedure may delay other essential treatments [9].
Although TAE was initially successful in ceasing arterial bleeding on angiography, a drop of hemoglobin subsequently might need additional intervention. One 25 year-old patient whose initial TAE was done at main splenic artery with coils deployment received a repeat angiography on day 2 because of a drop of hemoglobin. Although no active arterial bleeder was found at the second angiography, a second TAE at the main splenic artery using additional coils and gelfoam pieces was performed because the main artery was still partially patent despite previous coil deployment. The drop of hemoglobin was successfully arrested after the procedure. The other 57 year-old patient whose initial TAE was done at branch artery with coils deployment also had a drop of hemoglobin and a distended abdomen. He received splenectomy on day 8 at the discretion of surgeons. There was no active splenic hemorrhage at surgery but only a segment of floating spleen and 2000 mL of old hemoperitoneum. In retrospect, this patient could have been managed by a second spleen TAE rather than the more invasive splenectomy. The elevation of his intra-abdominal pressure as a result of the massive old hemoperitoneum could also be relieved by percutaneous catheter drainage. If the spleen was the only organ of injury and an initial spleen TAE was successful in arresting the splenic hemorrhage, then the continuous drop of hemoglobin is suggestive of a periodic slow hemorrhage [12, 17]. This slow hemorrhage could be attributed to an ineffective tamponade by the previously formed blood clot or a recurrent bleeding as a result of a return of normal blood pressure from a hypotensive status. Therefore, if a continuous drop of hemoglobin occurs despite a successful initial TAE in a hemodynamically stable patient, a repeat spleen TAE that is similar to a second-look surgery can be effective and relatively non-invasive for correcting the slow hemorrhage.

In this retrospective study, we were not able to control the usage of embolic agents. They were selected at the discretion of each radiologist. Nevertheless, coils deployment was selected for the majority of patients in this series. We agree that gelfoam particles should not be injected at the main splenic artery because it would result in a large splenic infarct. Moreover, splenic abscess has an association with large infarct caused by gelfoam embolotherapy [15, 17]. In our series, gelfoam particles were used in three patients of branch-artery TAE, one (33.3%) of whom developed splenic abscess. Therefore, even though spleen TAE is done superselectively at branch-artery, we still recommend that gelfoam particles be used only when coils are unavailable or when coil deployment is technically unsuccessful.

Although branch-artery TAE directly stop the active bleeder whereas the main-artery TAE reduces the blood flow in order to facilitate a clot formation, we found that people accepted branch-artery alone TAE had a higher risk of complications than people accepted main-artery alone TAE. If a branch-artery TAE was selected to stop a distal active bleeder, then an additional main-artery TAE might prevent the patients from the occurrence of post-TAE events as demonstrated in our study. Because the number of patients in this group was small, this potentially beneficial embolotherapy method has to be verified by a larger series.

Patients with multiple trauma and a transient response to fluid resuscitation are at higher risks of becoming unstable in hemodynamic condition during TAE procedure [18, 19]. In our series, one patient of multiple trauma died during TAE procedure. If the multiple injuries involve a cavitary bleeding, then a damage control surgery is more appropriate than TAE. Angiographic embolotherapy is reserved for concurrent pelvic surgery with retroperitoneal hemorrhage and only after the cavitary bleeding is checked by damage control surgery.

One 79 year-old man in our series died of pneumonia, sepsis, and multiple organ failure on day 22 despite a successful and effective spleen TAE. It has been stated that the elderly patients with splenic injury and high injury severity score should be judged with care for non-operative management because they are at a greater risk for failure [19, 20]. Although spleen TAE can increase the salvage rate of non-operative management in the elderly patients [21], an early damage control by surgical means might decrease the amount of fluid transfusion and hence reduce the transfusion related morbidity. It is therefore controversial as to whether or not the need and timing for surgical treatment in hypotensive elders have to be weighed differently.

The major limitation of this study was the small number of patients. Statistical analysis of the relationships between risk factors and types of TAE was not convincing. The second main limitation was that this retrospective study contained many uncontrollable variables. The third limitation was that we could not compare our TAE results with a control group because it is impossible and unethical. We did not routinely use CT to evaluate the volume.
of splenic infarct after splenic TAE. Whether or not there was compensatory hypertrophy of the preserved spleen was not addressed in this study.

In conclusion, patients with blunt splenic injuries who have CT findings of active hemorrhage or transient response to fluid resuscitation can be effectively treated with TAE. The association between risk factors (effectiveness, complications, outcomes) and types of embolotherapy had no statistical significance, however, it seemed that people who accepted branch-artery alone TAE had a higher risk of complications than people who accepted main-artery alone TAE. If a branch-artery TAE was selected to stop a peripheral active bleeder, then an additional main artery TAE was indicated to lower the potential risk of post-TAE event.

**REFERENCES**


動脈栓塞術有效治療流血不止或對輸液有短暫反應之脾臟鈍傷

黃成之 1 王俐人 1 黃耀祥 1 吳政賢 1 劉穎杉 1 傅真如 1 陳煥武 1 方禎鋒 2

長庚大學 林口長庚紀念醫院 急重症影像診療科 1 外傷急症外科 2

脾臟鈍傷的病人，若在臨床斷層檢查中發現有急性出血，或是對輸液治療僅有暫時效果者，可施以導管動脈栓塞術加以治療。本回溯性研究的目的在決定不同方式的栓塞治療之有效性，併發症，及病人最終的療效。

從 2001 年 1 月到 2004 年 12 月，總共回顧了 30 位接受脾臟栓塞治療成年病人的病歷。其中一位多重外傷的病人，在血管栓塞治療過程中死亡，被排除在此研究之外。剩餘 29 位病人中，9 位病人（31.0%）接受選擇性脾動脈分枝的栓塞，17 位病人（58.6%）接受脾動脈主幹栓塞，3 位病人（10.4%）同時接受脾動脈主幹及其分枝的栓塞，有 2 位病人（6.9%）於栓塞術後仍發生持續的血紅素下降。2 位病人（6.9%）於栓塞術後有產生脾臟瓣膜症。29 位病人無一死亡於脾臟相關的出血。以接受選擇性脾動脈分枝栓塞的病人和接受脾動脈主幹栓塞的病人做比較，前者發生栓塞後併發症的 odds ratio 為 2.00 (95% CI: 0.11, 36.31)。以接受選擇性脾動脈分枝栓塞的病人和非接受選擇性脾動脈分枝栓塞的病人做比較，前者發生栓塞後併發症的 odds ratio 為 2.38 (95% CI: 0.13, 42.83)。

本研究之結論是，不同方式的栓塞治療與其有效性，併發症，及病人最終的療效，並無統計學上有意義的相關性。然而，接受選擇性脾動脈分枝栓塞的病人比接受脾動脈主幹栓塞的病人似乎有較高的風險產生併發症。