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Evaluation of Need for Operative Intervention in Blunt Splenic Injury: Intraperitoneal Contrast Extravasation has an Increased Probability of Requiring Operative Intervention

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Abstract

Background Angioembolization is an effective adjunct to the management of blunt splenic injuries (BSI) that are not surgically treated. However, in some cases patients are unable to undergo angioembolization due to changes in their hemodynamic condition. In this study we attempt to define the characteristics of patients who need angioembolization in high-grade BSI.

Methods We retrospectively reviewed the charts of patients with BSI between January 2004 and June 2008. Patients with contrast extravasation (CE) on computed tomography (CT) scan were enrolled. The demographics, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS), the amount of blood transfused, and the type of CE were analyzed.

Results A total of 69 patients were enrolled. Patients with intraperitoneal CE in BSI required a higher rate of immediate operation due to changed hemodynamics. Furthermore, these patients displayed higher ISS and higher blood transfusion amounts.

Conclusions In BSI patients, intraperitoneal CE is associated with a higher possibility of requiring surgical intervention. Early surgical intervention should be considered in BSI patients with intraperitoneal CE or with ISS $\geq$ 25.

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Introduction

The spleen is the most commonly injured solid organ in blunt abdominal trauma [1]. Prior to the late twentieth century, surgical intervention was the standard treatment for blunt splenic injury (BSI); however, in recent decades, the standard treatment for spleen injury has transitioned from routine splenectomy to a policy of splenic preservation and nonoperative management (NOM) [2–6]. Currently, NOM is attempted in 60–80% of patients with splenic injuries and is successful in 85–94% of such cases [7, 8]. The development of interventional radiology in combination with NOM has resulted in a splenic salvage rate as high as 80–98% [2, 9–12]. On the other hand, post-traumatic splenectomy is typically associated with increased postoperative morbidity and mortality and long-term impairment of humoral and cellular immunity [13, 14].

It is widely accepted that NOM is able to be applied to hemodynamically stable patients, wherein angioembolization is advantageous in preserving the spleen and maintaining hemostasis [2–8]. Unfortunately, angioembolization is a time-consuming procedure, and, furthermore, close monitoring and resuscitation are usually difficult in an angiographic suite and radiologists are not always readily available in every hospital. All of these factors could result in an inadvertent delay in performing celiotomy for these potentially unstable patients, which could adversely affect their outcome. Thus, some initially stable patients may become unstable while receiving NOM and angioembolization, necessitating an emergency celiotomy. Previous reports have described several unfavorable factors for NOM in patients with BSIs, including older age, liver cirrhosis, a large hemoperitoneum, the need for blood transfusion, a high-grade splenic injury, and a high Injury Severity Score (ISS) [15–22].

As a result, it is important to investigate the factors that are highly associated with hemodynamic deterioration. In this study we investigated the characteristics of patients with BSIs in relation to computed tomography (CT) findings that predict hemodynamic deterioration during the time required for angioembolization preparation. We evaluated the correlation between CT characteristics and the clinical course to determine the most appropriate management regime for patients with BSIs and to demonstrate a pathognomonic clinical or CT finding that could be used to predict hemodynamic deterioration or nondeterioration at the emergency department (ED) or intensive care unit.

Materials and methods

We reviewed the trauma registry and medical records of patients with BSIs at the China Medical University Hospital (CMUH) from January 2004 to June 2008. CMUH serves as a major trauma referral center in the central part of Taiwan and serves a population of six million people. During this 54-month investigational period, patients with BSIs were identified and treated according to our established algorithm (Fig. 1). Patients with concomitant intra-abdominal free fluid that was visible via sonographic examination and who had unstable hemodynamics underwent an immediate celiotomy without further CT analysis. A CT scan was used to evaluate intra-abdominal organ injuries in the secondary survey of patients with stable hemodynamics, and subsequent treatments were based on the observed hemodynamic stability and CT scan findings. Patients who presented with a sustained BSI and who showed abnormal vascular findings on a CT scan, including contrast extravasation (CE), pseudoaneurysm, or arteriovenous (AV) fistula, were included in this study. These patients were expected to receive angioembolization for further hemostasis; however, some patients became hemodynamically unstable during the time required for angiography preparation and underwent

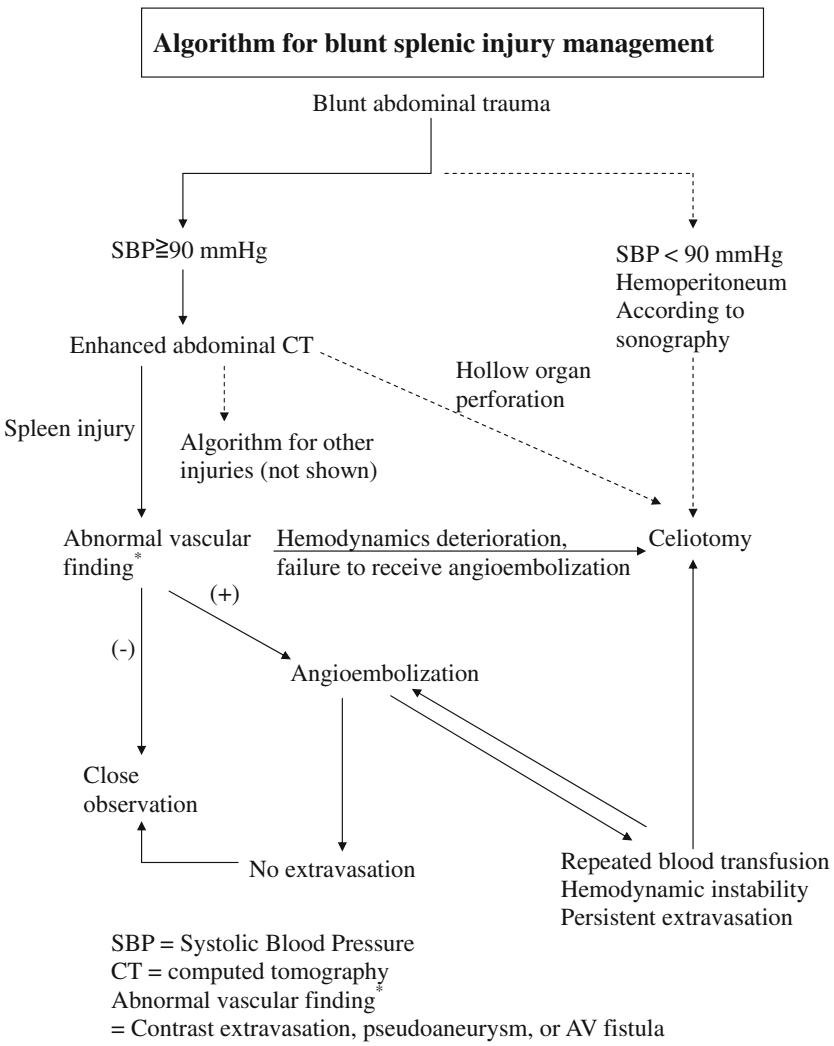

Fig. 1 Algorithm for BSI management

emergency celiotomy. Therefore, these patients were divided into two groups. Group I included patients who received angioembolization and recovered without complication. Group II included patients who exhibited hemodynamic deterioration during the time required for angioembolization preparation and received immediate celiotomy.

The exclusion criteria for this study were as follows: (1) patients who received immediate celiotomy due to unstable hemodynamics on arrival; (2) patients with other indications for celiotomy, such as hollow organ perforation; and (3) patients with other major extra-abdominal or extrasplenic causes of hemorrhage.

The demographic characteristics, grade of splenic injury, Abbreviated Injury Scale (AIS) score, ISS score, required blood transfusion amount (milliliters) before a procedure (angioembolization or operation), prothrombin time (PT)/international normalized ratio (INR), and type of CE were evaluated. The CT scan images were interpreted by both board-certified radiologists and trauma surgeons at the ED. The interventional radiology team was available full-time so that the angioembolization could be initiated within 1 h at our institution.

We used χ^2 tests and Wilcoxon two-sample exact tests to conduct univariate analyses. A P value of <0.05 was considered to be significant. A multivariate logistic regression analysis was performed to determine whether age, male gender, intraperitoneal CE, or ISS $\geq$ 25 (score) were independently related to patients not being able to receive angioembolization due to hemodynamic deterioration.

Results

During the 56-month study period, a total of 178 patients were admitted to CMUH with a diagnosis of BSI; 109 of them were excluded from the study due to the aforementioned criteria. Therefore, 69 BSI patients with abnormal vascular findings in the initial CT scan were enrolled. Forty-two patients who received subsequent angioembolization were categorized as Group I, whereas the remaining 27 patients who were unable to receive angioembolization due to hemodynamic deterioration and consequently received immediate celiotomy were categorized as Group II (Fig. 2). Of these 69 patients, nine presented with minor

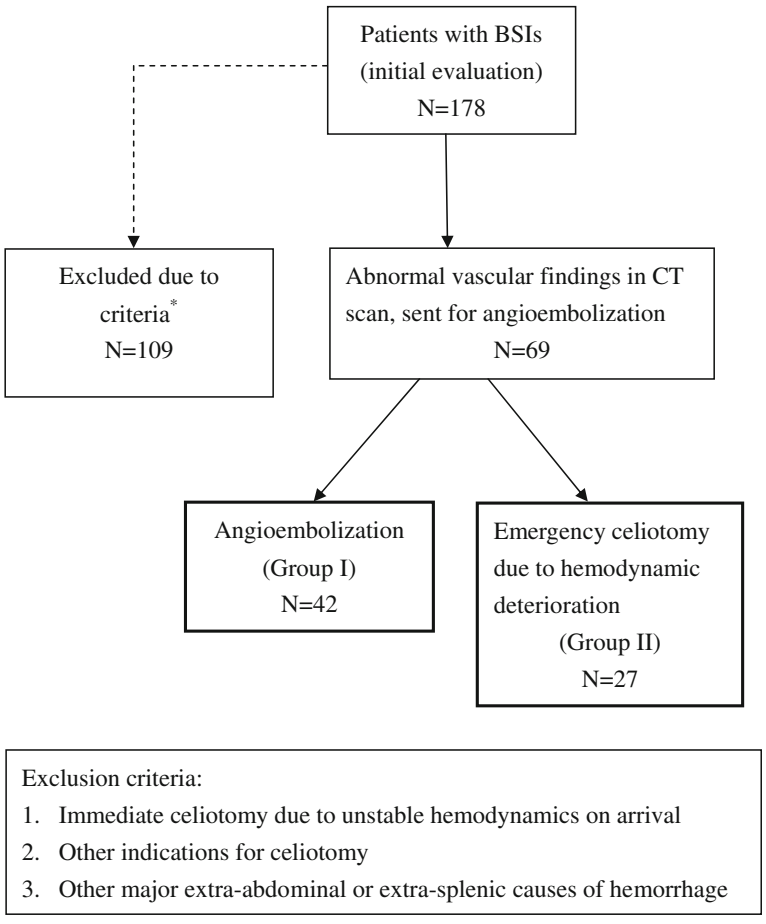

Fig. 2 The distribution of patients

renal injuries or hepatic injuries and 48 presented with extra-abdominal injuries.

The mean age of these 69 patients was 38.1 ± 22.4 years. Forty of the patients were male (58.0%) and 29 were female (42.0%). Age, gender, PT/INR, and the grade of the splenic injury were similar between the two groups (Table 1). The AIS, ISS, and amount of blood transfused were significantly higher in Group II in comparison to Group I (3.5 ± 0.5 vs. 3.1 ± 0.7, $P = 0.030$; 25.3 ± 13.2 vs. 17.8 ± 9.8, $P = 0.019$; 1531.7 vs. 675.6 ml, $P < 0.001$, respectively). In addition, there was no significant difference between these two groups with respect to the time interval between diagnosis and intervention (46.7 ± 21.4 vs. 57.5 ± 24.8, $P = 0.084$). In Table 2, 88.2% patients with intraperitoneal CE (Fig. 3) developed hemodynamic deterioration during the time required for angioembolization preparation, and only 12 of 52 patients (23.1%) with intraparenchymal CE (Fig. 4) were unstable prior to receiving angioembolization ($P < 0.001$).

The aforementioned multivariate logistic regression analyses revealed that the presence of intraperitoneal CE and an ISS ≥ 25 were two significant factors in the prediction of hemodynamic deterioration in patients waiting for angioembolization (Table 3). Patients with intraperitoneal CE (odds ratio [OR] = 81.6) and an ISS ≥ 25 (OR = 12.1) had a significantly higher probability of hemodynamic deterioration despite their initial stable status.

Table 2 The type of CE on CT scan between group I and group II

Variables	Intraperitoneal CE ($N = 17$)	Intraparenchymal CE ($N = 52$)	P value
Outcome			<0.001
Group I ($N = 42$)	2 (11.8%)	40 (76.9%)	
Group II ($N = 27$)	15 (88.2%)	12 (23.1%)	

CE contrast extravasation

Discussion

Angioembolization is thought to be a valuable adjunct in the NOM of abdominal solid organ injury [2–4, 23]. The proposed indications for angioembolization include large hemoperitoneum and abnormal splenic vascular findings on the initial CT scan [15, 23, 24]. Recent radiological technology is capable of completing a full-body CT scan in a very short time frame; hence, CT findings could help physicians make the best treatment decisions for their patients. When patients with isolated splenic injuries without vascular lesions were closely monitored in the ICU or ward during NOM, there was an 80–98% splenic salvage rate [2, 9–12]. On the other hand, angioembolization was considered if there were abnormal vascular findings on the initial CT scan.

In the current study, the failure rate of NOM in patients with BSIs was 15.2% (27/178); however, in as many as 39.1% (27/69) of patients, angioembolization could not be

Table 1 Demographics of the 69 splenic injuries with CE on the initial CT scan

Variables	Group I ($N = 42$)	Group II ($N = 27$)	P value
Age (years)	33.9 ± 19.0	44.6 ± 26.0	0.065*
Gender (N)			0.282**
Female	15 (35.7%)	14 (51.9%)	
Male	27 (64.3%)	13 (48.1%)	
Blood transfusion (ml)	675.6 ± 799.7	1541.7 ± 1209.4	0.001*
PT/INR	1.20 ± 0.18	1.24 ± 0.21	0.386*
Grade of injury, N (%)			0.06
Grade I	0 (0%)	0 (0%)	
Grade II	3 (7.1%)	0 (0%)	
Grade III	28 (66.7%)	14 (51.9%)	
Grade IV	11 (26.2%)	12 (44.4%)	
Grade V	0 (0%)	1 (3.7%)	
Time interval between diagnosis to intervene (min)	46.7 ± 21.4	57.5 ± 24.8	0.084*
AIS (Score)	3.1 ± 0.7	3.5 ± 0.5	0.030*
ISS (Score)	17.8 ± 9.8	25.3 ± 13.2	0.019*
ISS (N)			0.028**
≥25	11 (26.2%)	15 (55.6%)	
<25	31 (73.8%)	12 (44.4%)	

Valuables are mean ± SD

PT/INR prothrombin time/International normalized ratio; *CE* contrast extravasation; *ISS* injury severity score; *AIS* abbreviated injury scale

Group I: Patients were indicated to angioembolization (AE), then received this procedure smoothly. Group II: Patients were indicated to AE, but hemodynamics deteriorated in the preparation of AE. Then they received immediate celiotomy

* Wilcoxon two-sample exact test

** χ^2 test

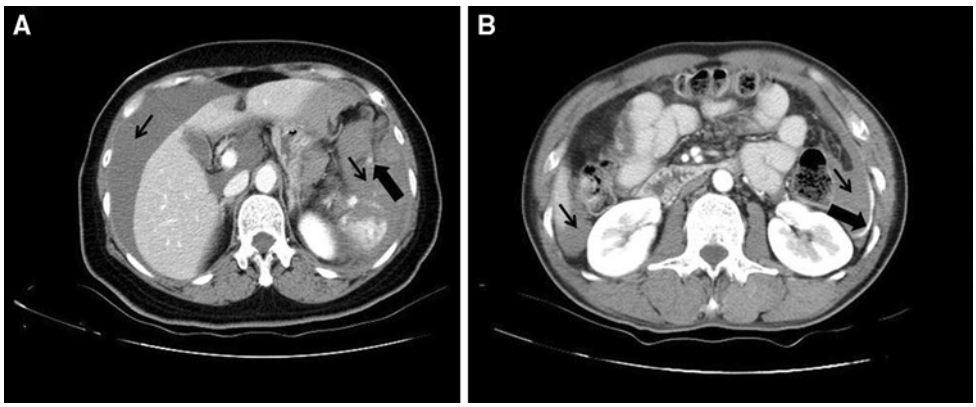

Fig. 3 CT scans for two BSI patients who failed to receive angioembolization due to hemodynamic deterioration. The *small arrows* indicate prominent hemoperitoneum, and the *large arrows* indicate intraperitoneal CE

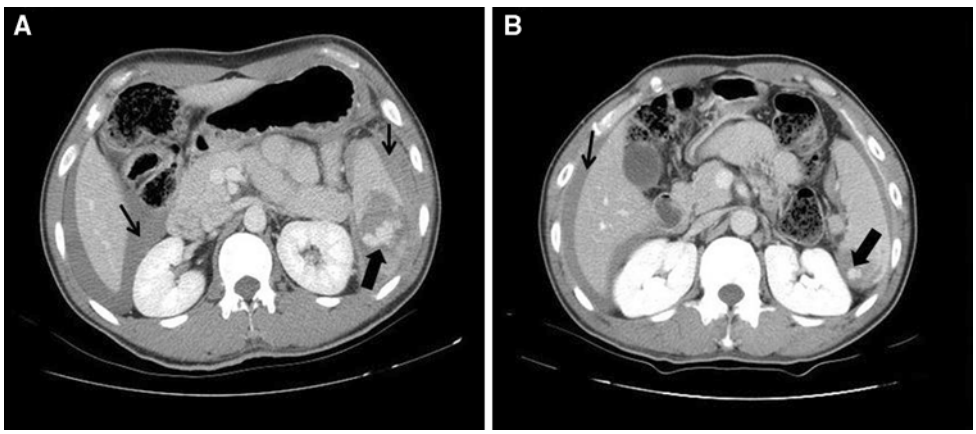

Fig. 4 CT scans for two BSI patients who were able to receive angioembolization. The *small arrows* indicate prominent hemoperitoneum, and the *large arrows* indicate CE confined to the parenchyma of the spleen

administered because of abnormal vascular findings in the initial CT scan. Although emergency celiotomy could be promptly undertaken, any possible sequelae after massive transfusion would delay recovery, prolong hospitalization, or even worsen to sepsis or multiple organ failure [13, 14]. We observed that those patients with intraperitoneal CE (Fig. 3) exhibited a significantly higher percentage of hemodynamic deterioration during the time required for angioembolization preparation, which resulted in patients' failing to receive angioembolization (88.2 vs. 11.8%, $P < 0.001$) (Table 2). In contrast, most patients with intraparenchymal CE (Fig. 4) without contrast intraperitoneal leakage were able to wait for angioembolization (76.9 vs. 23.1%). Therefore, the presence of intraperitoneal CE in the initial CT scan study indicates that early surgical intervention should be considered. Otherwise, hemodynamic instability due to ongoing bleeding might be more likely. Multiple logistic regression analysis also revealed that intraperitoneal CE was an independent risk factor for requiring surgical intervention, which was associated with an 80-fold increased risk of requiring an operation (OR = 81.6) (Table 3).

Table 3 Factors independently associated with patients unable to receive angioembolization due to changed hemodynamics

Variable	Odds ratio (95% CI)	*P* value*
Age ≥65 years	6.4 (1.02, 39.40)	0.047
Gender (male)	0.3 (0.06, 1.25)	0.096
Intraperitoneal contrast extravasation	81.6 (9.79, 680.41)	<0.001
Injury severity score ≥25	12.1 (2.34, 62.77)	0.003

* Multivariate logistic regression

Many studies have reported that the observation of CE in a CT scan is a specific sign of vascular injury and active hemorrhage [25, 26]. Invasive hemostatic procedures such as angioembolization or celiotomy are usually required when CE is detected in a CT scan. Fang et al. [27] have reported that the pooling of contrast material in the peritoneal cavity in patients with blunt hepatic injuries might represent either a massive or a direct active hemorrhage into a relatively low-pressure space. They have also suggested that without the tamponade effect of the hepatic capsule, its clinical course might be different from that of localized intraparenchymal CE. Our results revealed similar findings in patients with BSIs; however, the relationship between an ongoing splenic hemorrhage and the violation of splenic capsule has yet to be determined. On the other

hand, to the best of our knowledge, few reports in the English literature have discussed the significance of the CE pattern in BSI and further study is needed.

Several reports have indicated that the need for blood transfusion is a risk factor for NOM failure, and, furthermore, it has been observed that blood transfusion increases mortality in the NOM of blunt hepatic or splenic injuries. In addition, the amount of blood transfused (range = 1–4 units) was also associated with NOM failure [19–22]. In our study, the patients who failed to receive angioembolization due to hemodynamic deterioration needed more blood transfused than those who did receive it (1541.7 ± 1209.4 vs. 675.6 ± 799.7 ml, respectively, $P = 0.001$).

Another important factor in splenic salvage in BSI patients is injury severity. In our study we found that the AIS score of patients with BSIs was significantly higher in patients who were unable to receive angioembolization than that of those who did (3.5 vs. 3.1, $P = 0.030$). Furthermore, their ISS scores were also significantly higher than the scores of patients who received angioembolization without complications (25.3 vs. 17.8, $P = 0.019$). Therefore, in addition to intra-abdominal organs, other associated extra-abdominal injuries might also be more severe in these patients, which suggests that BSI patients with higher ISS scores have an increased probability of requiring surgical intervention. Thus, similar to previous reports, conservative management might fail in BSI patients with higher ISS scores [15].

This study was limited by the small number of examined cases and by its retrospective nature. We recognize the weaknesses of this study, including the small sample size and possible bias in case selection that may limit our conclusions. Nevertheless, these results do indicate and emphasize the characteristics of BSI patients who are initially in stable condition but become unable to receive angioembolization due to hemodynamic deterioration. Further studies with larger sample sizes and prospective designs are needed to establish algorithms for prompt diagnoses and precise treatment plans in the emergency department.

Conclusion

In BSI patients, intraperitoneal CE was associated with a greater need for surgical intervention. Early surgical intervention should be considered in BSI patients with intraperitoneal CE or with ISS ≥ 25 before the onset of hemodynamic deterioration.

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