

Treatment Option for High Grade Spleen Injury and Predictive Factors for Non-operative Management

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Purpose: Purpose: The prognostic factors of non-operative management (NOM) in high-grade spleen injuries have been extensively studied, but factors that would help treatment decisions are lacking. We compared the characteristics of the patients to identify the factors affecting treatment choices.

Methods: This is a review of 207 blunt spleen injury patients from January 2004 to December 2013. We compared clinical features and mortality between surgery and NOM, and used multivariate regression analysis to find the factor most strongly associated with prognosis.

Results: Of the 207 patients, 107 had high-grade spleen injury patients (grade III or above). Of these, 42 patients underwent surgery and 65 patients underwent NOM. The mortality was 7% following surgery, 3% with NOM. The amount of packed red blood cells transfused in the first 24 hours and spleen injury grade were associated with management type, and mortality was highly associated with activated partial thromboplastin time (aPTT) and spleen injury grade.

Conclusions: The grade of spleen injury was associated with management and mortality, so correctly assessing the spleen injury grade is important.

Keywords: Spleen injury; Blunt trauma; Non-operative management

INTRODUCTION

The spleen is the organ most often injured from blunt abdominal trauma [1]. Current management trends are shifting from immediate splenectomy to non-operative management (NOM). NOM should be considered for patients who are hemodynamically

stable, lack of peritoneal signs, and capable of treatment by monitoring serial evaluations, with an operating room available for emergency laparotomy [2]. The benefits of spleen conservation include preservation of spleen function, avoiding complications after splenectomy, including overwhelming post-splenectomy sepsis [3]. The selective application of embolization has resulted in increasing success of NOM. However, in high grade spleen injuries, prognostic factors to help with treatment decisions are unclear. The variables considered important in many studies are patient age, concurrent trauma, spleen injury grade, abbreviated injury score (AIS), injury severity score (ISS), injury mechanism, initial vital signs, and initial blood test results [4,5]. If clearly applicable factors for management choices, whether NOM or surgery, can be described, that will be very useful.

The object of this study is to review 10 years of experience of treatment for blunt spleen injury and identify predictive factors.

METHODS

Our study was a retrospective study using medical records of 247 patients admitted to a university hospital between January 2004 and December 2013 for blunt spleen injury who had contrast enhanced computed tomography scans and confirmed spleen injuries. We excluded patients under 15 years old. The exposure variable of interest was surgery versus NOM. We compared patient characteristics (age, sex, injury mechanism), AIS, ISS, and spleen injury grade. Spleen injury grading follows the American Association for the Surgery of Trauma (AAST) Splenic Injury Scale [6-8] (Table 1).

The same comparison was made in patients with spleen injury grade III or above, and variables that were significantly related to management and mortality were analyzed [9,10].

Initial status, clinical features and mortality of the patients and their values were compared by the management types (surgical patients [SP] and NOM). Among these, categorical variables were expressed using chi-square analysis, and continuous items we are compared using independent sample t-test. We used bivariate regression analysis to assess factors associated with mortality and management type as the odds ratio [11]. We rejected null hypotheses of no difference if *p*-values were less than 0.05.

RESULTS

During the study period, 247 patients were hospitalized and among them, patients under 15 years of age were excluded. Children tend to have a slight degree of injury compared to adults at the same trauma. For example, in the case of in car traffic accident (TA), an adult often seats in the front seat as a driver, while children often wear seat belts in the back seat, resulting in a low degree of injury to children. Capsules of the spleen are thicker than adults, and the elastin and smooth muscle contents of the blood vessels and capsules of the spleen are large, so they are more resistant to injury and more resilient than adults. Therefore, the treatment direction is different for adults and children, and basic treatment methods are also different. For this reason, we excluded children younger than 15 years (n=40) [12]. Of the 207 patients, there were 160 (77.3%) NOM patients, mean age of 41.6±15.8 years. There were 40 (22.7%) surgical patients, with mean age

Table 1. Grading of splenic injury (American Association for the Surgery of Trauma Organ Injury Scale)

Grade ^a	Description
I	Sub capsular hematoma <10% of surface area; laceration <1cm parenchymal depth
II	Sub capsular hematoma,10-50% of surface area, <5 cm in diameter; laceration, 1-3 cm in depth
III	Sub capsular hematoma >50% of surface area or expanding; laceration >5 cm depth or expanding; intraparenchymal hematoma, >3 cm or expanding
IV	Laceration involving segmental or hilar vessels producing major revascularization
V	Completely shattered spleen; hilar injury that devascularizes the entire spleen

^aAdvance 1 grade for multiple injuries up to grade III.

of 41.1±16.1. Table 2 compares clinical characteristics by treatment type. The most common injury mechanism was an in-car crash (72 patients) and 17 patients (37.2%) underwent surgery. The second most common cause was out-of-car crash, 55 patients (34.4%), of whom 13 (27.7%) were surgical and 26.9% were NOM. Other mechanisms were slip, sports injury, and violence, and the SP or NOM ratios of these patients were 12 (25.5%) and 32 (20.0%), respectively. One patient (2.1%) underwent surgery for grade I, and splenectomy was performed due to mesenteric bleeding, with spleen and vascular injury detected during emergency laparotomy. There were 46 (28.8%)

grade I NOM patients. Among grade II patients, four patients (8.5%) underwent surgery and 49 (30.6%) were NOM. Among grade III, there were 20 (42.6%) SP and 58 (36.3%) NOM, while grade IV included 15 (31.9%) SP patients and seven (4.4%) NOM. All seven grade V patients had surgery. This means the higher spleen injury grades are more likely to be treated surgically [13].

The AIS did not differ significantly in the head, neck, chest, and extremity, but the abdomen AIS grade differed significantly between surgical and NOM patients. The overall ISS in surgical patients was 22.5±25.7, and in NOM cases 16.4±9.4 ($p=0.001$).

We classified the patients by NOM and SP, and com-

Table 2. Clinical features of 207 patients with blunt spleen injury

	OP (n=47)	NOM (n=160)	p-value
Age	41.1±16.1	41.6±15.8	0.839
Sex			0.295
Male (n=165 [79.7])	40 (85.1)	125 (78.1)	
Female (n=42 [20.3])	7 (14.9)	35 (21.8)	
Injury mechanism			0.577
In car TA	17 (36.2)	55 (34.4)	
Out car TA	13 (27.7)	43 (26.9)	
Fall down	5 (10.6)	30 (18.8)	
Others ^a	12 (25.5)	32 (20.0)	
AIS			
Head	2.7±0.5	2.7±0.8	0.869
Neck	2.0±0.8	1.8±0.8	0.707
Chest	2.9±0.7	2.7±0.7	0.070
Abdomen	3.4±0.8	2.4±0.7	0.000
Extremity	3±0.5	2.9±1.6	0.771
ISS	22.49 ± 25.82	16.38±17.86	0.001
Spleen injury grade			<0.001
I	1 (2.1)	46 (28.7)	
II	4 (8.5)	49 (30.6)	
III	20 (42.6)	58 (36.2)	
IV	15 (31.9)	7 (4.4)	
V	7 (14.9)	0 (0.0)	

Values are presented as mean±deviation or number (%).
OP: operation, NOM: non-operative management, TA: traffic accident, AIS: abbreviated injury scale, ISS: injury severity score.

^aOthers: slip, sports injury, violence.

Table 3. Initial clinical features and management, outcomes of 207 patients

	OP (n=47)	NOM (n=160)	p-value
Hb	11.6±2.7	12.7±2.3	0.006
SBP	107.8±27.8	117.5±29.2	0.051
Platelet (×10 ³)	187.7±82.1	218.1±80.4	0.024
aPPT (sec)	35.2±15.8	29.5±6.3	0.020
INR	1.49±1.8	1.2±1.3	0.285
Lactate	3.4±2.7	2.7±2.3	0.113
BE	-5.1±5.4	-4.5±4.7	0.489
Management			<0.001
Emergency OP	43 (91.5)	0 (0.0)	
Delayed OP	4 (8.5)	0 (0.0)	
Embolization	0 (0.0)	9 (5.6)	
Conservative mx.	0 (0.0)	151 (94.4)	
Transfusion			
pRBC	19.5±16.1	7.2±8.8	0.001
PC	10.7±14.8	6.8±9.6	0.192
FFP	9.4±9.1	4.5±6.2	0.020
ICU stay (days)	9.8±13.5	9.4±10.3	0.872
Hospital stay (days)	25.9±24.9	27.7±26.2	0.853
In hospital mortality (%)	7 (14.9)	5 (3.1)	0.036

Values are presented as mean±deviation or number (%).
OP: operation, NOM: non-operative management, Hb: hemoglobin, SBP: systolic blood pressure, aPPT: activated partial thromboplastin time, INR: international normalized ratio, BE: base excess, mx.: management, pRBC: packed red blood cell, PC: platelet, FFP: fresh frozen plasma, ICU: intensive care unit.

pared their initial hemoglobin level, systolic blood pressure, international normalized ratio (INR), platelet, activated partial thromboplastin time (aPTT), lactate, Base-excess (Table 3). The results showed that the NOM patients' values were closer to normal than the SP patients. Of the surgical patients, 91.5% (43 patients) received emergency surgery (immediate splenectomy) and four patients (8.5%) were switched to surgery (delayed splenectomy) during non-operative management. The activated PTT of NOM patients 29.5 ± 6.3 sec was significantly lower than in the SP patients 35.2 ± 15.8 seconds ($p=0.020$). Significantly more blood in first 24 hours was needed in patients managed surgically (SP 19.5 ± 16.2 packs, NOM 7.2 ± 8.8 packs, $p<0.001$). This was similar to the amount of fresh frozen plasma (FFP) and platelet transfusions. Intensive care unit stay was 9.8 ± 13.5 days for SP and NOM 9.4 ± 10.3 days, not significantly different. The mortality rate of NOM 3.1% was significantly lower than SP patients 14.9% ($p=0.036$).

The same comparative analysis was performed in 107

patients with spleen grade III or higher high spleen injury. Their mean age was SP 40.3 ± 16.6 , NOM 39.7 ± 15.5 , and in-car TA was the most frequent injury mechanism, similar to overall patients, but there are no significant differences between the two management types. In high grade spleen injury, abdomen AIS was significantly higher in patients managed by surgery (Table 4).

Most test results of high grade patients in SP case were more abnormal than NOM cases, but the differences were not significant. With activated PTT, the surgical were 36.2 ± 16.4 seconds and non-surgical patients were 29.6 ± 5.6 seconds ($p<0.017$). The surgical patients consumed an average of 20.1 ± 17.1 packs of packed red blood cells (RBCs) in the first 24 hours, more than the NOM patients: a significant difference compared with other blood products (Table 5).

Mortality of surgically managed high grades patients was 16.7% and NOM was 4.6%. This was similar to the overall mortality (SP 14.9%, NOM 3.1%), meaning higher mortality rates at higher ratings, but the NOM never-

Table 4. Clinical features of grade \geq III patients

	OP (n=42)	NOM (n=65)	p-value
Age	40.3±16.6	39.7±15.5	0.845
Sex			0.197
Male (n=85)	36 (85.7)	49 (75.4)	
Female (n=22)	6 (14.3)	16 (24.6)	
Injury mechanism			0.053
In car TA	15 (35.7)	18 (27.7)	
Out car TA	13 (31.0)	19 (29.2)	
Fall down	2 (4.8)	16 (24.6)	
Others ^a	12 (28.6)	12 (18.5)	
AIS			
Head	2.7±0.5	2.7±0.7	0.878
Neck	2.0±0.8	2.1±0.9	0.800
Chest	2.9±0.7	2.9±0.6	0.963
Abdomen	3.6±0.7	2.9±0.4	<0.001
Extremity	3.0±0.5	2.9±0.6	0.506
ISS	23.7±10.9	19.7±10.4	0.063

Values are presented as mean±deviation or number (%).

OP: operation, NOM: non-operative management, TA: traffic accident, AIS: abbreviated injury score, ISS: injury severity score.

^aOthers: Slip, sports injury, violence.

Table 5. Initial clinical features and management, outcomes of grade \geq III patients

	OP (n=42)	NOM (n=65)	p-value
Hb	11.6±2.7	12.1±2.0	0.267
SBP	107.9±28.3	112.4±27.4	0.445
Platelet ($\times 10^3$)	181.8±78.8	211.3±84.9	0.074
PTT (sec)	36.2±16.4	29.6±5.6	0.017
INR	1.2±0.3	1.3±1.7	0.806
Lactate	3.4±2.8	2.6±1.6	0.093
BE	-5.1±5.5	-4.4±4.8	0.528
Transfusion (packs)			
pRBC	20.1±17.1	2.6±1.6	0.003
PC	11.1±15.2	4.6±8.6	0.109
FFP	9.7±9.6	5.1±8.2	0.097
ICU stay (days)	9.8±14.3	11.7±13.2	0.631
Hospital stays (days)	27.4±25.7	30.0±26.5	0.625
In hospital mortality (%)	7 (16.7)	3 (4.6)	0.036

Values are presented as mean±deviation or number (%).

OP: operation, NOM: non-operative management, Hb: hemoglobin, SBP: systolic blood pressure, PTT: partial thromboplastin time, INR: international normalized ratio, BE: base excess, pRBC: packed red blood cell, PC: platelet, FFP: fresh frozen plasma, ICU: intensive care unit.

Table 6. Factors associated with operative management and mortality for blunt spleen injury

	Exp (B)	95% CI	p-value
Factors associated with management			
RBC transfusion	0.918	0.858-0.982	0.012
aPTT	1.101	1.052-1.153	<0.001
Spleen injury grade \geq III	0.207	0.061-0.700	0.011
Factors associated with mortality			
aPTT	1.226	1.063-1.413	0.005
Spleen injury grade \geq III	9.253	1.779-48.123	0.008

CI: confidence interval, RBC: red blood cell, aPPT: activated partial thromboplastin time.

theless had a lower mortality rate. This means that even higher-grade patients can be considered for conservative management, and this is our main opinion.

We conducted bivariate regression analysis to identify factors associated with management types and mortality of blunt spleen injury patients. Variables associated with management type were the amount of packed RBC transfused within 24 hours, activated PTT and high grade spleen injury. The mortality-related variables were activated PTT and spleen in patients with high grade spleen injury (Table 6).

DISCUSSION

Non-operative management of hemodynamically stable blunt spleen injury is currently accepted as a standard option. NOM means surgical observation with serial physical examination, serial computed tomography, or angiographic embolization. Research reports the success rate of NOM is 78% to 98% [14]. With the development of angiographic intervention, the success rate increased up to 98% [15]. In high grade spleen injury of grade III and above, the prognostic consideration for treatment decision is unclear [16]. In a study by Olthof et al. [17], in hemodynamically stable patients, the factors affecting the failure of NOM were age 40 and older, spleen injury grade \geq III, ISS \geq 25, abdominal AIS \geq 3, trauma and injury score (TRISS) $<$ 0.8. Watson et al. [18] reviewed 3,085

adults, and found that failure of NOM AIS \geq 4 was up to 54.6%. Other studies on the relationship between failure of the NOM and the ISS note higher failure rates of NOM if the ISS is greater than 25 [19].

Rossaint et al. reported that it is important to monitor initial hemoglobin and coagulation factors in major trauma where massive bleeding is expected, such as spleen injury. Lactate and base deficit are sensitive tests to estimate and monitor the extent of bleeding and shock [20,21].

In our study, the factors affecting treatment and prognosis of blunt spleen injury were age, injury mechanism, spleen injury grade, initial vital status, CBC, coagulation battery, and the amount of transfusion in first 24 hours. These variables were compared by treatment type (NOM or SP), followed by bivariate regression analysis of the factors that were significantly different. The spleen injury grade, activated PTT, and the amount of transfused red blood cells were associated with surgical treatment of high grade spleen injury. We concluded that it could be more beneficial to consider NOM because the mortality of NOM was lower than surgery in even high spleen injury grade patients.

Our study had considerable limitations. The patient records of this study included 10 years of data before establishment of the trauma center in this hospital, so there could be many omissions. The study sample size was small. Most patients were of similar age, making comparisons of age differences difficult. Thus the importance of age, as mentioned in the literature, could be undervalued. During our patient's treatment periods from 2004 to 2014, the intervention team for emergency embolization had not full-time activated. All grade V patients underwent surgery; therefore we could not obtain information about high grade spleen injury angiographic embolization results. Gaarder et al. [22] analyzed the effect of angiographic embolization in severe spleen injuries on outcomes measured by laparotomy and splenectomy rates for mandatory embolization in grade 3 to 5 whenever positive angiographic findings. They found that angiographic embolization use resulted in an increase of patients selected for NOM from 57% to 73% and failure rate decrease from 21% to 4% [22]. Another shortfall of our study was having no data about in high grade spleen injury patients converted from NOM to delayed operation. The infor-

mation was limited to surgery management or NOM, making it impossible to assess prognostic factors. Despite these limitations, our study's significance is confirmation of the importance of spleen injury grade in blunt trauma of spleen and analysis of definitive factors that affect treatment options. Further study analyzed by the cost effectiveness of treatment options, patient heterogeneity, and post NOM complications like pseudo-aneurysm or delayed hemorrhage is needed [23-25].

CONCLUSION

In conclusion, mortality of high grade spleen injury patients was higher than low grade injuries, and mortality of NOM patients was lower than in surgically managed patients. The factors that affect the treatment options in high grade splenic injury were aPTT and spleen injury grade.

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