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CLINICAL RESEARCH

SCIENCE MONITOR Received: 2016.11.18 **Clinical and Radiological Presentations and** Accepted: 2017.01.10 Published: 2017.07.12 **Management of Blunt Splenic Trauma:** A Single Tertiary Hospital Experience ABEF 1 Gaby Jabbour Authors' Contribution: Study Design A ABE 1 Ammar Al-Hassani Data Collection B Corporation, Doha, Oatar Ayman El-Menyar ACDE 2,3 Statistical Analysis C ABCF 1 Husham Abdelrahman Data Interpretation D Manuscript Preparation E ADF 1 **Ruben Peralta** Literature Search E

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Material/Methods:

Background:

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Splenic injury is the leading cause of major bleeding after blunt abdominal trauma. We examined the clinical and radiological presentations, management, and outcome of blunt splenic injuries (BSI) in our institution.

Dds: A retrospective study of BSI patients between 2011 and 2014 was conducted. We analyzed and compared management and outcome of different splenic injury grades in trauma patients.

Results: A total of 191 BSI patients were identified with a mean (SD) age of 26.9 years (13.1); 164 (85.9%) were males. Traffic-related accident was the main mechanism of injury. Splenic contusion and hematoma (77.2%) was the most frequent finding on initial computerized tomography (CT) scans, followed by shattered spleen (11.1%), blush (11.1%), and devascularization (0.6%). Repeated CT scan revealed 3 patients with pseudoaneurysm who underwent angioembolization. Nearly a quarter of patients were managed surgically. Non-operative management failed in 1 patient who underwent splenectomy. Patients with grade V injury presented with higher mean ISS and abdominal AIS, required frequent blood transfusion, and were more likely to be FAST-positive (p=0.001). The majority of low-grade (I–III) splenic injuries were treated conservatively, while patients with high-grade (IV and V) BSI frequently required splenectomy (p=0.001). Adults were more likely to have grade I, II, and V BSI, blood transfusion, and prolonged ICU stay as compared to pediatric BSI patients. The overall mortality rate was 7.9%, which is mainly association with traumatic brain injury and hemorrhagic shock; half of the deaths occurred within the first day after injury.

Conclusions: Most BSI patients had grade I-III injuries that were successfully treated non-operatively, with a low failure rate. The severity of injury and presence of associated lesions should be carefully considered in developing the management plan. Thorough clinical assessment and CT scan evaluation are crucial for appropriate management of BSI.

MeSH Keywords: Abdominal Injuries • Spleen • Wounds, Nonpenetrating

 Abbreviations:
 BSI – blunt splenic injury; BAT – abdominal trauma; NOM – non-operative management;

 CT – computerized tomography; INR – international normalized ratio

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Background

Splenic injury is the leading cause of major bleeding in blunt abdominal trauma (BAT) patients [1]. In earlier practice, blunt splenic injury (BSI) was managed surgically in most cases (OM) with splenectomy in adults, but splenorrhaphy was the preferred alternative for splenic salvage in children due to risk of overwhelming post-splenectomy infection and sepsis (OPSI) [2]. The diagnosis and management of BSI have significantly evolved over the past few decades [3]. The increased understanding of splenic function in immunological process and identification of post-splenectomy complications have led physicians to prefer the non-operative management (NOM) [4]. There is increasing evidence of the success of the NOM approach in adult BSI patients with hemodynamic stability [5,6]. Currently, NOM has high success rates in pediatric (≥95%) and adult (≥80%) BSI cases, as supported by the management guidelines of the Eastern Association for the Surgery of Trauma (EAST) [7,8]. The guidelines of BSI management depend on the hemodynamic status of the patient and the grade of splenic injury in accordance to the American Association of Surgery of Trauma Organ Injury Score (AAST-OIS), which divides the splenic injury into 5 grades (grades I and II are low grades, grades IV and V are high grades, and grade III is intermediate). Splenic salvage with NOM is considered in hemodynamically stable patients who have low-grade BSI, whereas splenectomy is indicated in hemodynamically unstable patients or those who had anatomic injury beyond repair (mostly grade IV and V) [9]. Abdominal CT scan remains the preferred diagnostic modality in patients presenting with minimal findings on clinical examination [10]. Dual-phase imaging can readily diagnose splenic injury grades, pseudoaneurysms, hemoperitoneum, and nonvascular injuries, which helps in the selection of an appropriate management plan [11]. With advanced diagnostic modalities, NOM becomes possible even in selected high-grade BSI cases [12]. Moreover, angiographic procedures are also preferred in selected cases due to their diagnostic and therapeutic implications, with the potential to increase the success rate of NOM and to deal with some of the possible splenic complications of the NOM approach. Splenic angioembolization increases the success rate of NOM through control of active bleeding and coiling of splenic pseudoaneurysm, thus helping to avoid delayed splenic rupture [13]. Therefore, diagnostic and therapeutic angiography has become an adjunct method for successful NOM in BSI [14]. Despite the high incidence of BAT [15], there is a paucity of information describing BSI in the Arab Middle-East. We examined the frequency, grades, clinical presentation, management, and outcomes in patients with BSI over a period of 3 years from a single center in Qatar.

Material and Methods

We conducted a retrospective study of all BSI patients admitted to the Level I Trauma Center, Hamad General Hospital (HGH), in Qatar from June 2011 to June 2014. Inclusion criteria were all BSI patients admitted to the hospital with complete relevant data regardless of patient age and sex. Hemodynamically stable patients proven to have BSI by CT scan were selected for NOM and were closely monitored in the trauma intensive care unit (TICU). All patients with penetrating abdominal trauma and patients declared dead on arrival were excluded from the study. Hemodynamic instability was considered as a drop in systolic blood pressure of more than 30 mmHg and hypotension (systolic blood pressure under 90 mmHg) in spite of adequate fluid resuscitation. The diagnosis and grading of BSI were confirmed by CT scan or intra-operative findings. Indications for surgery in our institution included hypotension on admission plus positive FAST, other associated abdominal injuries (e.g., perforated viscus, bladder injuries, and diaphragmatic injuries), acute abdomen, persistent hypotension after receiving 2 units of PRBCs, consultant clinical discretion, and failure of NOM. Indications for NOM were hemodynamic stability and fluid response requiring ≤ 2 units of blood.

Indications for angioembolization (part of NOM) included CT scan findings of "positive blush/contrast extravasation" or pseudoaneurysm in hemodynamically stable or fluid-responder patients.

Failure of angioembolization was defined as persistent bleeding (e.g., clinical correlations with persistent hypotension, low hemoglobin, and increased base deficit).

Data analysis included patients demographics, clinical characteristics, mechanism of injury, vital signs, Glasgow Coma Score, associated injuries, laboratory investigations (hemoglobin levels on admission, at 24 h and 48 h, platelet count, lactate, base excess, and INR), initial and repeat CT scan findings, splenic injury grades, blood transfusions, management (conservative, surgical, or interventional radiology), intra-operative findings, failure of NOM, ventilatory days, length of hospital and ICU stay, and mortality. BSI was categorized into different grading scales (I–V) [9]. We compared management and outcomes according to splenic injury grades, management approach (operative vs. NOM), and age group (pediatric vs. adult). Ethics approval was obtained from the Medical Research Center (IRB# 14409/14) at Hamad Medical Corporation, Doha, Qatar.

Statistical analysis

Data are presented as proportions, mean \pm standard deviation, or median, as appropriate. Baseline demographics, clinical presentation, management, and outcomes were compared

according to splenic injury grades using one-way ANOVA for continuous variables and Pearson chi-square (χ^2) for categorical variables. Patients' hospital outcomes were also analyzed according to age and management approach, using the *t* test for continuous variables and Pearson χ^2 test for categorical variables. Fisher's exact test was used if the expected cell frequencies were below 5. For skewed continuous data, the nonparametric Mann-Whitney test was performed. Two-tailed pvalues <0.05 were considered significant. Data analysis was carried out using the Statistical Package for the Social Sciences version 18 (SPSS Inc., Chicago, IL, USA).

Results

Of the total 1500 cases of polytrauma per year, blunt abdominal trauma constitutes around 15%. During the study period, 191 patients had BSI, which constitutes around 22% of the annual blunt abdominal trauma admissions. Males represented 86% (n=164) of BSI cases, with a mean age of 26.9±13.1 years (Table 1). The most frequent causes of BSI were traffic-related accidents (70.5%), fall from height (19.5%), ATV rollovers (3.2%), and fall of heavy objects (2.6%). The most commonly associated injuries were chest (60.7%), other solid organs (35.1%), and head (25.7%). However, patients with chest trauma had overlapping frequencies of rib fracture (45.5%), lung contusion (34.6%), pneumothorax (19.4%), and hemothorax (8.4%). Similarly, 67 (35.1%) splenic injury patients also had involvement of other solid organs, such as the liver (19.9%), kidneys (17.8%), and pancreas (4.2%). FAST was positive in 68 (35.6%) cases. The major findings on initial CT scan evaluation (n=171) were splenic contusion and hematoma (77.2%), splenic laceration (29.8%), shattered spleen (11.1%), blush (11.1%), and devascularization (0.6%). Repeat CT scan (n=26) showed improvement in 9 (34.6%), no improvement in 14 (53.8%), and worsening of contusions in 3 (11.5%) cases. Three (11.5%) cases were found to have pseudoaneurysmal lesions on repeat CT scan, which were treated by angioembolization. The most frequent intra-operative findings were splenic avulsion/pelvic/ retroperitoneal hematoma (16.8%), mesenteric contusion/tear (1.6%), and pancreatic contusion (1.0%). Grade II (36.1%) splenic injuries were most common, followed by grade III (30.3%), grade I (11.5%), grade IV (11%), and grade V (11%).

The mean injury severity score was 21.5 ± 11.5 and median abdominal AIS was 2 (range; 2–5). Nineteen percent of cases sustained severe traumatic brain injury (GCS <8) and blood transfusion was required in 48.4% cases [median, range: 4 (1–51) units of packed red cells] (Table 1). Forty-five (23.6%) patients were managed operatively (1 case underwent splenorrhaphy) and 146 (76.4%) were treated conservatively (3 had angioembolization). Failure of NOM was observed in 1 patient (0.5%) who underwent splenectomy due to worsening abdominal pain and hypotension; the patient was successfully treated without postoperative complications. The median lengths of hospital and ICU stay were 7 (1–304) and 3 (1–57) days, respectively.

Table 2 presents the patients' demographics, clinical presentation, and outcomes according to splenic injury grades. Patients with grade IV splenic injuries were the youngest (p=0.01) and had the lowest systolic blood pressure (p=0.001) at presentation to the Emergency Department. Grade V splenic injury patients presented with higher mean ISS and abdominal AIS, required more frequent blood transfusions, and were more likely to be FAST-positive (p=0.001 for all).

The laboratory findings at baseline and follow-up did not differ significantly with respect to splenic injury grades (Table 3). Patients with grade V had lower hemoglobin and higher INR at baseline.

Figure 1 shows the distribution of associated injuries according to splenic injury grades. The frequency of chest injuries was non-significantly higher in patients with grade III and IV splenic injury. Grade III and IV patients also had more head injuries, whereas patients with grade I and II injuries were more likely to sustain other solid organ injuries (P>0.05 for all). Figure 2 shows the management algorithm and grades of BSIs.

Table 4 shows the management and outcome by splenic injury grades. The majority of patients with grade (I–III) splenic injuries were treated conservatively, and patients with high-grade (IV and V) BSI frequently required operative intervention (splenectomy) (p=0.001). Of the 45 patients who underwent splenectomy, 25 underwent CT scan and 20 were operated on urgently without CT scan. The distribution of splenectomy (with and without CT scan), angioembolization, and failure of NOM were comparable among the different grades. Moreover, the median lengths of hospital and ICU stay were comparable with respect to splenic injury grades. The overall mortality rate was 7.9% (15 patients) and patients with grade IV and V splenic injuries were more likely to die due to other associated injuries (Table 5). Overall, severe traumatic brain injury (TBI) was the most frequent cause of death (10 out of 15 deaths). The highest mortality was observed within the first day (53.3%), followed by the first week (26.7%), and more than 1 week (20.0%). Of the 3 patients who died with a grade V splenic injury, 2 deaths occurred due to irreversible shock and bleeding (died within 1 day) and 1 died of TBI after 3 days of injury. Among grade IV splenic injury patients, 2 died secondary to severe TBI, and 1 had traumatic cardiac arrest (all died within 1 day). TBI was also the main cause of death in patients with low-grade BSI, which usually occurs within 1 week after injury.

Adult patients with BSI were more likely to be males, had higher frequency of grade II, I and V injuries (Table 6, Figure 3),

Table 1. Demographics, clinical presentation and outcome of blunt Splenic injury patients (n=191).

Variable	Value		Variable	Value	
Age (Mean ±SD)	26	5.9±13.1	Blush	19	(11.1%)
Male	164	(85.9%)	Shattered spleen	19	(11.1%)
Mechanism of injury			Devascularization	1	(0.6%)
Motor vehicle crash	134	(70.5%)	Repeat CT (n=26)		
Fall from height	37	(19.5%)	Improvement	9	(34.6%)
All-terrain vehicle (ATV)	6	(3.2%)	No improvement	14	(53.8%)
Fall of heavy object	5	(2.6%)	Worsening of contusions	3	(11.5%)
Assault	4	(2.1%)	Pseudoaneurysm	3	(1.6%)
Others	5	(2.6%)	Splenic injury grades		
Systolic blood pressure (<90 mmHg)	20	(10.7%)	I	22	(11.5%)
GCS (<8) in ED	36	(19.1%)	ll	69	(36.1%)
Associated injuries			III	58	(30.3%)
Rib fracture	87	(45.5%)	IV	21	(11.0%)
Lung contusion	66	(34.6%)	V	21	(11.0%)
Pneumothorax	37	(19.4%)	Blood transfusion	92	(48.4%)
Hemothorax	16	(8.4%)	Blood units transfused	4	(1–51)
Head injury	49	(25.7%)	Interval from arrival to OR (hrs)	2.0	(0.38–120)
Hepatic	38	(19.9%)	Treatment		
Kidney	34	(17.8%)	Conservative (NOM)#	146	(76.4%)
Pancreas	8	(4.2%)	Operative management##	45	(23.6%)
Bowel/mesenteric	9	(4.7%)	Intervention radiology*	3	(1.6%)
Stomach	1	(0.5%)	Failure of NOM**	1	(0.5%)
Major vascular injuries	5	(2.6%)	Injury Severity Score	21	l.5±11.5
Diaphragmatic Injury	1	(0.5%)	Abdominal AIS	2	(2–5)
FAST positive	68	(35.6%)	Hospital stay (days)	7	(1–304)
Initial CT scan (n=171)			ICU stay (days)	3	(1–57)
Contusion and hematoma ^{&}	132	(77.2%)	Ventilatory days	2	(1–27)
Splenic laceration	51	(29.8%)	Mortality	15	(7.9%)

CT – computed tomography; AIS – Abbreviated Injury Scale; ED – emergency department; GCS – Glasgow Coma Score; FAST – Focused Assessment with Sonography for Trauma; OR – operating room. * 3 cases found to have Pseudoaneurysm on repeat CT that were treated by angioembolization; ** underwent splenectomy, & Pelvic or retroperitoneal hematoma; # 3 cases had angioembolization, ## 1 case underwent splenorraphy.

	Grade I (n=22)	Grade II (n=69)	Grade III (n=58)	Grade IV (n=21)	Grade V (n=21)	P value
Age (Mean ±SD)	32.7±11.7	29.1±13.3	23.8±13.9	21.9±10.1	26.6±10.7	0.014
Male (%)	87.0	82.6	93.0	76.2	85.7	0.32
SBP in ED	117±18.4	124.8±26.2	113±27.7	99.2±32	103.5±30.9	0.001
SBP <90 (%)	4.5	5.8	14.8	23.8	9.5	0.11
GCS (<8) in ED (%)	22.7	20.3	18.2	9.5	23.8	0.76
ISS (mean ±SD)	20.8±12.5	17.4±10.3	22±9.8	24.9±12.6	31.3±10.5	0.001
Abdominal AIS	2.3±0.7	2.3±0.6	2.9±0.9	3.5±1.1	4.5±0.6	0.001
Blood transfusion (%)	39.1	34.8	44.6	71.4	90.5	0.001
FAST positive (n=68)	3 (13.0%)	14 (21.2%)	20 (40.0%)	12 (75.0%)	19 (90.5%)	0.001

Table 2. Demographics and clinical presentation according to splenic injury grades.

* Retroperitoneal, Pelvic or Psoas; INR - international normalized ratio.

Table 3. Laboratory findings.

	Grade I (n=22)	Grade II (n=69)	Grade III (n=58)	Grade IV (n=21)	Grade V (n=21)	P value
Haemoglobin						
At baseline	13.7±2.4	13.2±2.1	12.7 <u>+</u> 2.2	12.1±2.1	12.0±2.3	0.03
After 24 hrs	12.0±2.1	11.9±2.4	11.2±2.1	10.2±1.9	10.8±2.3	0.02
After 48 hrs	10.4±2.4	10.9±2.2	10.5±2.0	10.1±1.7	10.4±1.8	0.72
Serum lactate	2.9±1.4	3.4±2.1	3.8±3.3	3.8±3.1	3.7±1.9	0.68
Platelet count						
At baseline	244.4±46.4	261±86.7	280±113.6	228±81.7	225±55.9	0.06
After 24 hrs	169.8±50.6	191.4±73.4	169.7±80.6	175.6±65.2	147.9±50.3	0.15
After 48 hrs	145.1±60.3	166.8±83	157±56.8	172.4±68.1	151.4±46.6	0.66
Base excess	-5.4±3.2	-4.2±3.6	-5.8±4.9	-6.9±4.0	-6.7±3.7	0.12
INR	1.09±0.13	1.10±0.12	1.21±0.45	1.17±0.17	1.43±1.0	0.04

required more blood units to be transfused, and had prolonged ICU stay compared to the pediatric BSI cases. On the other hand, children sustained greater proportions of grade III and IV splenic injuries as compared to adults (p=0.03 for all). Notably, the injury severity, management, and mortality were comparable among the 2 groups.

Discussion

This unique study from Qatar which shows a high frequency of BSI, particularly after traffic-related accidents. Our findings are consistent with earlier studies that showed higher involvement of young males in MVC-related BSI [16,17]. The present study also observed chest and head regions as the most frequent concomitant extra-abdominal injuries. Some authors suggested increased risk of worse outcomes in polytrauma patients due to missed or delayed diagnosis of BSI [18,19]. High ISS suggestive of multiple trauma is considered as a prognostic factor for failed NOM in adults with BSI [18].

In our study, contusion and hematoma were the most frequent findings on initial CT scan, followed by splenic laceration and shattered spleen. Generally, a CT finding of contrast extravasation necessitates urgent surgical or interventional treatment. New data suggest routine angio- embolization for



Figure 1. Associated injuries categorized by splenic injury grades (P>0.05 for all).



Figure 2. Management algorithm and grades of blunt splenic injuries.

Table 4. Management and outcome by splenic injury grades.

	Grade I (n=22)	Grade II (n=69)	Grade III (n=58)	Grade IV (n=21)	Grade V (n=21)	P value	
Treatment							
Conservative	22 (100%)	67 (97.1%)	46 (79.3%)	8 (38.1%)	3 (14.3%)	0.001	
Operative management	0 (0.0%)	2 (2.9%)	12 (20.7%)	13 (61.9%)	18 (85.7%)	for all	
Splenectomy (n=45)							
Without CT scan (n=20)	0 (0.0%)	0 (0.0%)	3 (27.3%)	7 (53.8%)	10 (52.6%)	0.27	
With CT scan (n=25)	0 (0.0%)	2 (100%)	8 (72.7%)	6 (46.2%)	9 (47.4)	for all	
Angioembolization (Pseudoaneurysm)	0.0	1.4	1.8	0.0	4.8	0.71	
Failure of NOM	0.0	0.0	1.8	0.0	0.0	0.67	
Hospital stay (days)	8 (1–131)	10 (1–114)	7 (1–304)	7 (1–52)	6 (1–38)	0.79	
ICU stay (days)	4.5 (2–57)	5 (1–52)	2.5 (1–37)	2 (1–29)	2 (1–11)	0.08	
Mortality	2 (9.0%)	3 (4.3%)	4 (6.9%)	3 (14.3%)	3 (14.3%)	0.40	

Table 5. Cause of death in splenic injury cases (n=15).

No.	Cause of death	Splenic injury grades	Time to death
1	Internal bleeding, pelvic hematoma, spleen and liver injury, retroperitoneal hematoma, severe bleeding, shock	5	1 day
2	Traumatic brain injury (brain contusion, edema, anoxia) brain death	2	14 days
3	Polytrauma, head injury, traumatic cardiac arrest	3	1 day
4	Head injury	5	3 days
5	Traumatic cardiac arrest	4	1 day
6	Multiorgan failure, aortic injury + iliac injury	3	4 days
7	Traumatic cardiac arrest, severe head injury, chest and abdominal injury	3	2 days
8	ARDS, septic shock	2	6 days
9	Cardiac arrest, severe head injury, splenic injury	4	1 day
10	Severe head injury	3	1 day
11	Unsalvageable brain injury	4	1 day
12	Severe traumatic cardiac arrest, traumatic brain injury	2	1 day
13	Severe traumatic brain injury, fixed dilated pupil	1	10 days
14	Severe traumatic brain injury	1	14 days
15	Traumatic cardiac arrest, blunt abdominal trauma, bleeding, hematoma	5	1 day

high grade splenic injuries (Grade IV–V) and for patients with blush on the CT scan [11]. CT scan findings of blush may serve as a useful predictor of failed NOM [19]. In our study, initial CT scan revealed blush in 19 cases with a low rate of failed NOM (0.5%). However, patients with negative FAST had increased risk of missed intra-abdominal injuries due to the lower specificity of the test [20]. In the present study, 65% of BSI cases had negative or inconclusive FAST results, and were diagnosed mainly upon CT scan evaluation. Patients with lower splenic injury grades (I–III) were more frequent than high-grade (IV–V)

Table 6. Management and outcome of splenic injury by age (adult vs. paediatric group).

	Adults (n	=166; 87%)	Pediatric	(n=25; 13%)	P-value
Age (Mean ±SD)	30.1	l±10.9	6.3	l±3.6	0.001
Male (%)	148	(89.2%)	16	(64.0%)	0.001
Associated injuries					
Head	43	(25.9%)	6	(24.0%)	0.83
Lung contusion	57	(34.3%)	9	(36.0%)	0.87
Rib fracture	80	(48.2%)	7	(28.0%)	0.05
Hepatic	36	(21.7%)	2	(8.0%)	0.11
Bowel/mesenteric	8	(4.8%)	1	(4.0%)	0.85
Kidney	30	(18.1%)	4	(16.0%)	0.80
Pancreas	8	(4.8%)	0	(0.0%)	0.26
Splenic injury grades					
1	22	(13.2%)	0	(0.0%)	
ll	63	(38.0%)	6	(24.0%)	
III	45	(27.1%)	13	(52.0%)	0.03 for all
IV	17	(10.2%)	4	(16.0%)	
V	19	(11.4%)	2	(8.0%)	
Blood transfusion	82	(49.4%)	10	(41.7%)	0.47
Blood units transfused	5	(1–51)	2	(1–7)	0.005
Injury severity score	22.1	l±11.6	17.	5±10.1	0.06
Abdominal AIS	2	(2–5)	3	(2–5)	0.62
Treatment					
Conservative	124	(74.7%)	22	(88.0%)	0.14 for all
Operative management	42	(25.3%)	3	(12.0%)	
Hospital stay (days)	7	(1–304)	8	(1–38)	0.70
ICU stay (days)	3	(1–57)	2	(1–11)	0.007
Failure of NOM	1	(0.6%)	0	(0.0%)	0.69
Mortality	13	(7.8%)	2	(8.0%)	0.97

BSI in our cohort. Contrary to our findings, Al-Qahtani [16] reported higher frequency of grade IV/V BSI (62%), followed by lower grades (I–III).

CT-based scoring systems could be inaccurate for decisionmaking in some cases with small blush, which can be successfully treated non-operatively without the need for angioembolization. These scoring systems are best judged by the description and clinical status [21]. Moreover, the use of follow-up imaging is controversial as there is no consensus on its utility. Notably, repeat CT scan is not indicated in asymptomatic patients or those without clinical or laboratory evidence of bleeding; rather, it should be selectively considered in patients with worsening abdominal pain and in patients with suspected complications based on the surgeon's discretion [22]. In our series, 13.6% of cases underwent repeated CT; one-third of them showed an improvement and more than half showed no change in initial findings. Weinberg et al. [23] demonstrated that early repeat CT scan (within 24–48 h) helped to detect higher grade BSI, which could be successfully managed



Figure 3. Distribution of splenic injury grades (adults vs. children).

by angioembolization, but others investigators suggested no effect of follow-up imaging on the planned management [24].

A high index of suspicion, together with thorough clinical and hemodynamic assessment, presence of associated injuries, and CT findings, should be considered for the management of BSI [8]. Usually, NOM is considered for hemodynamically stable patients to preserve immune function, as well as to reduce postoperative complications and costs of hospitalization. Several studies have advocated the safety, efficacy, and high success rate of selective NOM [3,6]. In adults, successful NOM has been reported in up to 85% cases (failure rate $\approx 8-38\%$) [8]. Smith et al. [25] successfully treated 93% of the hemodynamically stable, low-grade (≤ 3) splenic injury patients with NOM. Consistent with these findings, three-fourth of our patients were managed conservatively; only 1 case had failed NOM, and underwent splenectomy later.

Usually, NOM is considered for patients with low-grade splenic injuries, unless operated upon for other associated injuries. In fact, higher-grade injuries could also be managed non-operatively with the liberal use of angioembolization [26]. Splenic angioembolization of bleeding vessels increases the success rate of NOM in hemodynamically stable patients [13], which could eliminate the need for operative management (OM) regardless of the splenic injury grade. In our series, 3 patients developed delayed splenic pseudoaneurysms and all were successfully treated by angioembolization. Similarly, Scalfani et al. [27] reported an 84% salvage rate for grade IV splenic injury managed by angioembolization. To increase the success rate of NOM, angioembolization could be considered in hemodynamically stable high-grade (IV-V) injury patients in the absence of blush [28].

Splenectomy should be considered for clinically unstable patients with devascularization, coagulopathy, associated injuries, and significant bleeding [12]. In our series, splenectomy was performed in one-quarter of the cases; they had hypotension, low hemoglobin levels, and higher ISS and INR and only 1 patient underwent splenorrhaphy. The rate of operative management was non-significantly higher among adults. However, an earlier study reported a higher rate of surgical management (44%) in adults [29].

Interestingly, the degree of successful NOM in adult and children varies due to intrinsic anatomic differences or involvement of other factors [3]. In children, NOM has become the standard of care, with a high success rate (75-93%) [25,30], and the reported frequency of NOM in adults is around 60% [31]. Consistent with earlier studies, children were more likely to be treated successfully with NOM than adults in our series. Di Saverio et al. [31] reported a lower rate of failed NOM in children (2%) as compared to adults (17%) with BSI, which is in agreement with our findings, as only 1 adult patient had failed NOM. Similar to our findings, an earlier study demonstrated higher injury severity in adults who sustained traffic-related accidents injuries. This could be explained by the greater possibility of kinetic energy transmission as compared to children, who have smaller body mass and lower impact [12]. Notably, Lippert et al. [30] observed an association between higher injury severity and prolonged hospitalization in adults, which could be attributed to other concomitant injuries rather than to NOM. Consistently, in our study, adults who sustained severe injuries required more units of transfused blood and had prolonged ICU stay. The overall mortality for splenic lesions with other associated injuries varies from 6% to 7% [32]. A recent study of splenic injury patients reported an overall mortality rate of 6% [33]. It has been suggested that the higher rate of mortality was mainly attributable to the associated injuries and post-traumatic complications [12]. In line with these findings, the overall mortality rate in our study was 7.9%; most deaths were due to severe traumatic brain injury or exsanguination from different sources. Recently, Frandon et al. [34] reported a lower mortality (3%) in the operative group, which is proportional to the overall injury severity.

The present study has certain limitations due to its retrospective design and potential for selection bias. The analysis was based on registry data; therefore, details of the operation and missed diagnoses could be imperfect. Moreover, there was no follow-up after hospital discharge to document any delayed postoperative complications.

Conclusions

NOM is the modality of choice for BSI and has a lower failure rate than other methods used in hemodynamically stable BSI patients. Successful NOM requires thorough consideration of clinical and radiologic details. Angioembolization is a valuable adjunct to NOM in selected BSI cases. Each institution should form a management algorithm for the best treatment of BSI based on the available resources and expertise.

Declarations

Ethics approval and consent to participate: Ethics approval was obtained from the Medical Research Center (IRB# 14409/14) and waiver consent was approved by the Hamad Medical Corporation, Doha, Qatar.

Competing interests: The authors declare that they have no competing interests.

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