Factors for failure of nonoperative management of blunt hepatosplenic trauma in children

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Background **Trauma is major cause of morbidity and mortality in children with blunt abdominal trauma; the most commonly injured organs are the liver and the spleen. A high rate of operative complications caused a shift from operative to nonoperative management (NOM) in patients suffering from hemodynamically stable blunt abdominal trauma. The aim is to evaluate factors for failure of NOM for blunt abdominal trauma that caused injuries of the liver and the spleen in children.**

Patients and methods **This study included 142 patients with blunt abdominal trauma with either hepatic or splenic injuries that were hemodynamically stable and treated initially by NOM. Patients had undergone a contrast computed tomography (CT) scan for grading injuries, contrast blush, and hemoperitoneum.**

Results **There were 17 patients with high-grade hepatic or splenic injury. Six of these 17 patients and two patients with low-grade injuries failed NOM. Moderate and large volumes of hemoperitoneum have been reported in 42 and nine patients, respectively, with failure rates of 7.1 and 44.4%. Fourteen patients had CT blush on CT scan; five of them failed NOM (failure rate of 35.7%). Two other patients needed laparotomy for intestinal injuries. Thus, the overall success rate of NOM was 93% (132 patients); 10 (7%) patients failed NOM.**

Conclusion **High-grade injuries, large hemoperitoneum, and contrast blush on the CT scan increase the risk of failure of NOM in patients with blunt hepatosplenic injuries. Nevertheless, most of these patients can be successfully managed with NOM. However, other than hemodynamic instability, the other factors mentioned above deserve further evaluation to determine their ability to aid in the decision between operative and NOM for blunt hepatosplenic injuries in children.** ***Ann Pediatr Surg*** **12:63–67 © 2016 Annals of Pediatric Surgery.**

Annals of Pediatric Surgery 2016, 12:63–67

Keywords: hepatosplenic injury, nonoperative, blunt

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Received 10 December 2015 **accepted** 19 March 2016

Introduction

Trauma is a major cause of morbidity and mortality in children. With blunt abdominal trauma, the most commonly injured organs are the liver and the spleen [1].

Since the 1980s, a high rate of operative complications have caused a paradigm shift from operative to nonoperative management (NOM) in hemodynamically stable blunt abdominal trauma patients [2,3]. Many authors published their experiences, with satisfactory results [3,4].

NOM can be safely practiced in a Trauma Care Centre that has trauma surgeons, newer imaging modalities, a high dependency unit, an ICU, and other supporting services [4]. Repeated clinical examination supplemented with modern imaging and laboratory investigations plays a key role in reaching therapeutic decisions, thus preventing unnecessary laparotomies [5].

Thus, in the hemodynamically stable child, NOM of hepatic and/or splenic injuries has become the current standard of care [6].

However, in the hemodynamically unstable child or in the child with signs or symptoms of peritonitis, an immediate operation is necessary [7,8].

The present study aimed to investigate factors that are responsible for failure of NOM of blunt hepatosplenic injuries.

Patients and methods

This is a prospective study to evaluate the factors for failure of NOM in children (aged 18 years and less) with blunt abdominal trauma with injuries to the liver and the spleen at Menoufia University Hospitals between May 2011 and May 2015.

The study included 142 patients who presented with blunt abdominal trauma with either hepatic or splenic injuries (with or without other injuries) that were treated initially by NOM. On arrival, all the patients were assessed and resuscitated if necessary, in accordance with the advanced trauma life support protocol. History including the mechanism of injury formed an important part of the evaluation. All patients underwent focused abdominal sonography in trauma/abdominal sonography. Stable patients with positive focused abdominal sonography in trauma were further evaluated with chest, abdomen, and pelvic computed tomography (CT) scan with intravenous contrast; all patients underwent routine laboratory investigations in the form of complete blood count (to get baseline hemoglobin and hematocrit), coagulation profile, and hepatic and renal profile. Patients with other associated injuries were examined by the respective specialists with close coordination. The exclusion criteria for rejecting NOM were signs of exsanguination, persistent hemodynamic instability, and no response to initial resuscitation or obvious bowel injury (signs of peritonitis). After clinical and radiological assessment of the patients, three parameters were

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documented and monitored: grade of injury, size of the hemoperitoneum, and contrast blush on CT scans. The presence of intra-abdominal fluid was determined using CT. The amount of hemoperitoneum was quantified as follows: minimal: perihepatic blood in the subphrenic space, subhepatic space, or perisplenic fossae (< 500 ml); moderate: minimal plus blood along the paracolic gutter (500–1000 ml); and large: moderate plus blood accumulating in the pelvic cavity (> 1000 ml). Contrast 'blush' on CT scan with intravenous contrast represents a well-circumscribed, hyperdense collection of intraparenchymal contrast material that indicates ongoing bleeding.

Only stable patients were included in the study and treated nonoperatively in the pediatric ICU or high-dependency unit. The protocol included evaluation of vitals, pulse, blood pressure, temperature, and urine output every hour for the first 12 h, then every 2 h for the next 12 h and then every 4 h for the next 24 h. The patients underwent daily follow-up with laboratory investigations. Surgical intervention was indicated during follow-up if the patients became unstable and developed tachycardia and hypotension or when there was a decrease in hematocrit by 10% over 24 h or a decrease in HGB by 1 g/dl over 24 h.

Patients managed by NOM were hospitalized at least for 1 week and discharged (unless indicated for hospitalization for associated injuries) when they were free of pain and follow-up ultrasound showed decreased or absence of hemoperitoneum and no expanding hematomas. Patients were instructed to return to regular activities when they were completely pain free. Participation in noncontact sports was allowed after 6 weeks and contact sports was allowed after 3 months with follow-up weekly at the outpatient clinic during the first month and every 2 weeks during the following 2 months.

Before the inclusion of the patients in the study, ethical clearance was sought from the competent authority of Menoufia University Hospitals. Written informed consent was obtained from the patients' relatives for publication of this research and any accompanying images.

Statistical analysis

The data were collected, tabulated, and analyzed by SPSS (Statistical Package for Social Science), version 17.0, on an IBM compatible computer (Chicago, Illinois, USA).

Two types of statistical analyses were carried out: Descriptive statistics in the form of percentage (%), mean (X), and SD. Analytical statistics in the form of the χ^2-test to study the association between two qualitative variables and the Z-test for comparison of two proportions in two independent groups.

Results

The study included 142 children: 111 boys (78%) and 31 girls (22%). The age range was 1–16 years (mean = 9.51 ± 3.63 years). Motor vehicle accident was the most common mechanism of injury in 122 children (85%). Fourteen children (9.9%) sustained injuries from falls, 10 (7%) from height, and four (2.8%) from the stairs. Six patients (4.2%) sustained injuries from kicks to the abdomen (either by humans or by animals).

The hepatic and splenic injuries were graded according to the American Association for Surgery of Trauma Organ Injury Scaling using CT scan findings (Figs 1–5). The distribution of hepatic and splenic injuries by grade is summarized in Table 1. Combined hepatic and splenic injuries occurred in 15 (10.6%) children (the total number of patients in Table 1 is 157 as 15 patients have been counted twice). The associated injuries in 98 (69%) children are shown in Table 2.

All patients underwent an abdominal CT, which revealed hepatic and/or splenic injuries. High-grade injuries are those with grade IV and above. There were 17 patients with high-grade injury (17/142; 12%): four patients had combined high-grade hepatic and high-grade splenic injuries; eight patients had high-grade hepatic injury; and five patients had high-grade splenic injury. Six of the 17 patients (6/17; 35%) with high-grade injuries failed NOM and needed laparotomy to stop bleeding; three of these six patients had combined injuries: one patient with isolated high-grade hepatic injury (grade V) and two patients with isolated splenic injury (grade V). All the six patients had to undergo laparotomy within the first 48 h (Table 3).

There were 125 patients with low-grade injuries. NOM was successful in 121 patients (121/125; 96.8%) and failed in four patients (4/125; 3.2%).

One patient with combined grade II hepatic and grade III splenic injury became hemodynamically unstable after 72 h, and follow-up CT of the abdomen with contrast showed increased hemoperitoneum and expanding splenic hematoma. The patient needed laparotomy. Splenectomy was performed and the bleeding from the hepatic tear ceased completely.

Table 1 Distribution of liver and spleen injuries in children with blunt trauma

Grade	Grade I	Grade II	Grade III	Grade IV	Grade V	Grade VI	Total
Liver	39 (45.3)	26 (30.2)	9 (10.5)	8 (9.3)	4 (4.7)	0 (0.0)	86
Spleen	24 (33.8)	28 (39.4)	10 (14.1)	7 (9.9)	2 (2.8)	–	71

Table 2 Associated injuries

Thoracic (n=42, 29.6%) [n (%)]	
Lung contusion	23 (16.1)
Hemothorax/pneumothorax	10 (7)
Rib fracture	17 (11.9)
Clavicle fracture	6 (4.2)
Skeletal (n=28, 19.7%) [n (%)]	
Femur fracture	5 (3.5)
Pelvis fracture	14 (9.8)
Humerus fracture	8 (5.6)
Tibia fracture	5 (3.5)
Head and neck (n=39, 27.5%) [n (%)]	
Head injury	23 (16.1)
Cervical fracture	5 (3.5)
Mandible and maxillary fracture	3 (2)
Abdominal (n=20, 14%) [n (%)]	
Renal injury	8 (5.6)
Adrenal hematoma	1 (0.7)
Retroperitoneal hematoma	9 (6.3)
Intestinal injury	2 (1.4)

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Table 3 Hepatosplenic injury grade as a factor for failure of nonoperative management in hepatosplenic injury

	Successful NOM [*n* (%)]	Failed NOM [*n* (%)]	*P* value
High-grade injury (17 patients)	11/17 (64.7)	6/17 (35.3)	0.09
Combined hepatosplenic injury (15 patients)	11/15 (73.3)	4/15 (26.7) (3 with high-grade and one with low-grade injuries)	0.03
Combined high-grade injuries (4 patients)	1/4 (25)	3/4 (75)	0.48
High-grade hepatic injury not associated with splenic injury	7/8 (87.5)	1/8 (12.5)	0.01
High-grade splenic injury not associated with hepatic injury	3/5 (60)	2/5 (40)	1.0
Combined low-grade injury (11 patients)	10/11 (90.9)	1/11 (9.1)	0.001
Low-grade hepatic injury not associated with splenic injury (71 patients)	71/71 (100)	0/71 (0)	<0.001
Low-grade splenic injury not associated with hepatic injury (56 patients)	55/56 (98.2)	1/56 (1.8)	<0.001
Total number of patients in the study (142 patients)	132/142 (93%)	10/142 (7) (8 due to hepatosplenic injuries and 2 due to occult intestinal injuries)	<0.001

Z-test was used for comparison.
NOM, nonoperative management.

Table 4 Hemoperitoneum as factor for failure of nonoperative management of hepatosplenic injury

	Minimal hemoperitoneum on initial CT	Moderate hemoperitoneum on initial CT	Large hemoperitoneum on initial CT
Total number of patients	91	42	9
Number of patients who failed NOM and needed laparotomy to stop bleeding in hepatosplenic injury	1	3	4
Percentage	1.1%	7.1%	44.4%
P value		<0.001	

χ^2-test was used.
CT, computed tomography; NOM, nonoperative management.

Table 5 Computed tomography contrast blush as a factor for failure of nonoperative management in hepatosplenic injury

	Contrast blush on initial CT	
	Negative	Positive
Total number of patients	128	14
Number of patients who failed NOM and needed laparotomy to stop bleeding in hepatosplenic injury	3	5
Percentage	2.3%	35.7%
P value	<0.001	

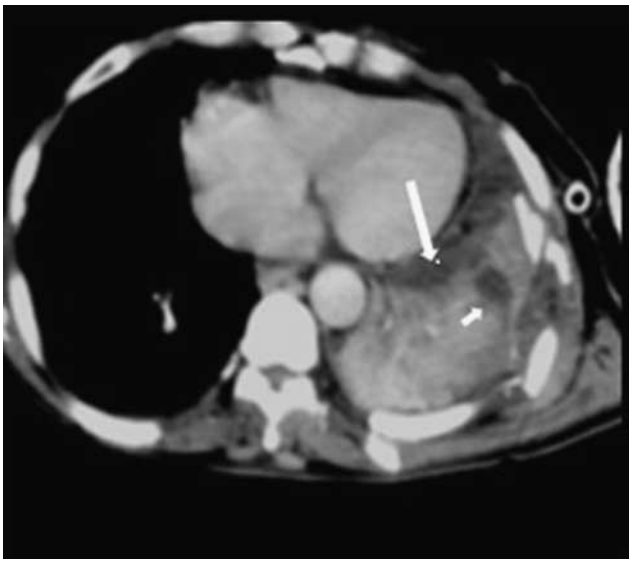
χ^2-test was used.
CT, computed tomography; NOM, nonoperative management.

Another patient with splenic injury grade III that was treated nonoperatively and who was discharged after 1 week of admission came back after 10 days with massive hematoma of the spleen that needed laparotomy and splenectomy for fear of rupture of the hematoma (delayed splenic rupture).

Two other patients needed laparotomy for occult intestinal injuries that were not obvious on admission. They developed signs of peritonitis, and pneumoperitoneum was obvious in the radiograph of the abdomen (one patient within the first 24 h and the other patient after 36 h).

Thus, overall 10 patients failed NOM (eight due to hepatosplenic injuries and two for intestinal injury) with overall success of NOM in 132 patients (93%).

Fig. 1



Splenic injury: splenic laceration less than 3 cm (short arrow) with perisplenic collection (long arrow) and associated rib fracture.

Table 4 (hemoperitoneum as a factor for failure of NOM in hepatosplenic injury) shows that percentage of failure of NOM was 1.1, 7.1, and 44.4% for minimal, moderate, and large hemoperitoneum, respectively, with a *P* value less than 0.001, which reflects statistical significance.

Table 5 (CT contrast blush as a factor for failure of NOM in hepatosplenic injury) shows that the percentage of failure of NOM was 2.3 and 35.7% in patients with negative contrast blush on CT and patients with positive contrast blush on CT, respectively, with *P* value less than 0.001, which reflects statistical significance.

Discussion

Blunt abdominal trauma is a common injury in childhood, with the liver and the spleen being the most frequently injured solid organs. Historically, operative therapy is the generally accepted method of treatment for blunt hepatosplenic injury [9]. The advantages are accurate assessment of solid and hollow visceral injury, coupled with prompt, expedient repair. However, the finding that

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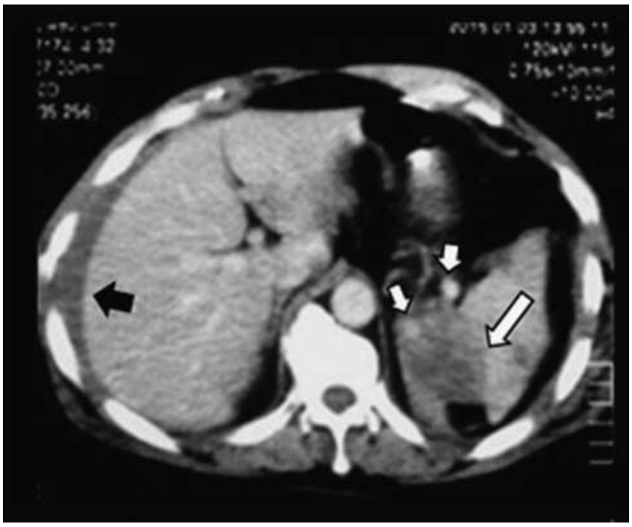
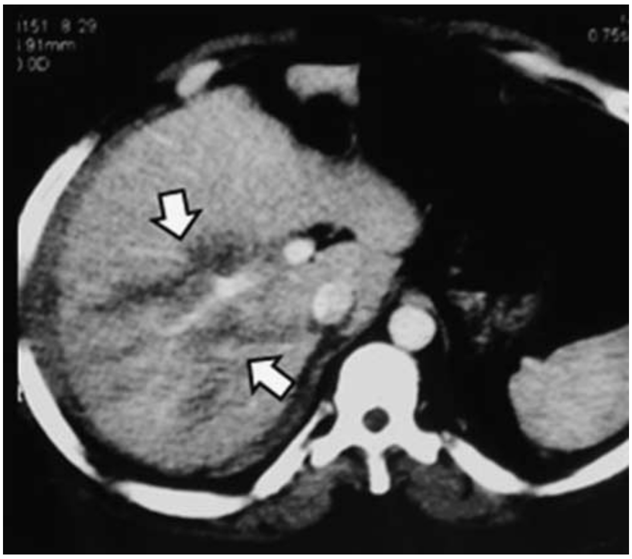
Fig. 2



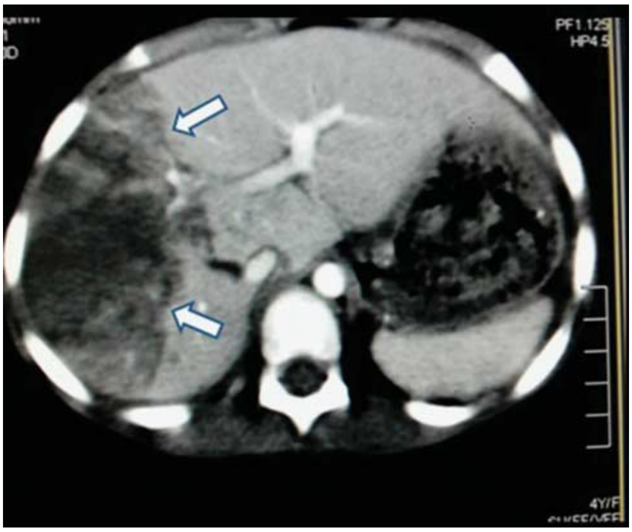
Splenic injury with contrast blush: splenic laceration more than 3 cm (long white arrow) with perihepatic collection (short black arrow) and contrast blush (short white arrow).

Fig. 3



Hepatic injury: hepatic laceration more than 3 cm (white arrow).

Fig. 4



Hepatic tear (grade IV).

Fig. 5

Splenic injury: shattered spleen.

between 20 and 67% of all hepatic and splenic injuries will stop bleeding at the time of laparotomy, coupled with the risk of developing major complications after surgery, led to the development of selective NOM [7].

The risk of overwhelming postsplenectomy infection after splenectomy depends primarily on the patient's age: the risk of developing overwhelming postsplenectomy infection is four times higher in children compared with adults [10]. This shows that avoiding laparotomy and splenic preservation is an especially important objective in the pediatric population. The initial management of blunt abdominal trauma in children should follow the standard trauma resuscitation guidelines. Immediate life-threatening injuries should be identified and treated. A hemodynamically unstable child with hemoperitoneum or with signs of abdominal injury should undergo laparotomy. Any child who is hemodynamically stable or who is rapidly stabilized after initial resuscitation should be managed by NOM. NOM of splenic and hepatic injuries was successful in 93% of children in this study, which compares favorably with other studies [11,12]. The success of nonoperative treatment of solid organ injury is dictated primarily by hemodynamic stability, which is the child's physiologic response to resuscitation, and not by the grade of the injury [12]. However, results of this study showed that high-grade injury, especially if it is a combination of high-grade hepatic and splenic injuries, is associated with statistically significantly increased risk for failure of NOM and that low-grade injuries are associated with statistically significantly increased rate of success of NOM. Those who oppose NOM of solid organ injuries argue that there might be complications such as

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abscesses, delayed hepatic or splenic bleeding, bilomas, and missed intestinal injuries [13].

However, these complications are uncommon in children; we encountered three in the current study: two cases of occult intestinal injury and one patient with delayed splenic hematoma.

The two patients with occult intestinal injuries were diagnosed and operated upon after starting NOM. The intestinal injuries were not obvious on the initial abdominal CT, and the main disadvantage of CT is a difficulty with diagnosing intestinal injuries. The presence of pneumoperitoneum without an extra-abdominal or iatrogenic cause, presence of air in the retroperitoneum, free intraperitoneal fluid without solid organ injury, focal areas of thickening of the bowel wall and mesentery, and leakage of contrast material from the bowel are all highly suggestive of intestinal injuries [14].

The volume of hemoperitoneum as a factor for failure of NOM has been assessed and reported in several studies to be associated with the failure of NOM [15,16]. There has been no clear consensus among the reported series regarding the methodology of grading hemoperitoneum on CT scan. Most describe the amount of hemoperitoneum as minimal, moderate, or large [16]. Usually the hemoperitoneum is seen in the Morison pouch, perihepatic and perisplenic spaces, in the right paracolic gutter, and in the pelvis and is reabsorbed 5 to 10 days after injury. In this study, moderate and large volumes of hemoperitoneum have been reported in 42 and nine patients, respectively, with failure rates of 7.1 and 44.4%, respectively, which reflected that quantity of hemoperitoneum was associated with a statistically significant increased risk for failure of NOM. It is important to note that most patients with large hemoperitoneum are hemodynamically unstable from the start and were not included in the study. Powell *et al.* [17] demonstrated an increased risk for failed NOM with increasing volumes of hemoperitoneum. Davis *et al.* [18] excluded all patients with large hemoperitoneum from their nonoperative group. Pachter *et al.* [19] reported lack of association between large hemoperitoneum and nonoperative failure rates, but they failed to provide any substantive data to support their contention. It appears that the data available at this time are not conclusive, although the need for surgical intervention seems to increase in the presence of moderate to large quantities of hemoperitoneum [20]. Contrast blush refers to extravasation of contrast from intraparenchymal vessels. Contrast can either collect within the parenchyma or flow outside of the injured organ. Contrast blush has been associated with higher NOM failure rates. Furthermore, contrast extravasation has been reported to increase the failure rate of NOM by 24 times [16]. In the current study, 14 patients had CT blush on CT scan: five of them failed NOM and needed laparotomy to stop bleeding (failure rate of 35.7%); this is considered a statistically significantly increased risk for failure of NOM.

Conclusion

High-grade injuries (grade IV or higher) or injuries with a large hemoperitoneum or injuries associated with the presence of contrast blush on the CT scan appear to increase the risk for failure of NOM of patients with blunt hepatosplenic injuries. However, most of these patients (more than 2/3 of them) can be successfully managed with NOM. Nevertheless, other than hemodynamic instability, the other factors mentioned above deserve further evaluation to determine definitively their ability to discriminate operative versus NOM of blunt hepatosplenic injuries in the pediatric age group.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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