Original Article

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Non-operative Management - The First Option in the Treatment of Blunt Liver and Spleen Trauma in Pediatric Patients

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Abbreviations:
NOM: non-operative management;
FAST: focused abdominal sonography for trauma;
CT: computed tomography;
US: ultrasound;
AAST: American Association for Surgery of Trauma;
APSA: American Pediatric Surgical Association;
OM: operative management;
Hb: hemoglobin;
Ht : hematocrit;
LOS: lenght of stay;
ECU: Emergency Care Unit;
ICU: Intensive Care Unit;
SBP: Systolic blood pressure;
HR: Heart rate.

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Rezumat

Managementul non-operator - prima opțiune de tratament a traumatismelor închise de ficat și splină la pacienții pediatrici

Scop: Scopul acestui studiu este de a evalua anumite caracteristici ale traumatismelor închise hepatice şi splenice la copii, şi procedurile şi eficiența managementului non-operator, pe o perioadă de 5 ani într-un spital terțiar de copii.
Material şi Metodă: Am realizat un studiu retrospectiv pe 32 de pacienți cu traumatism închis hepatic şi/sau splenic. Au fost evaluate vârsta, sexul, mecanismul de producere, nivelurile de hemoglobină şi hematocrit, numărul de zile de internare şi de repaus la pat, diagnosticul imagistic, hemostatice şi transfuzii, tratament, şi starea la externare.
Rezultate: 58% din pacienți au fost de sex masculin. Vârsta medie a fost 10,7 ani. Principalul mecanism de producere a fost accidentul rutier. Ecografia şi tomografia computerizată au găsit 56,2% traumatisme splenice, şi 43,8% traumatisme hepatice. Cele mai frecvente leziuni ecografice au fost lacerațiile, iar tomografic au dominat leziunile de grad III. 84,4% dintre pacienți au fost internați în serviciul de Anestezie şi Terapie Intensivă, iar 15,6% în secție. Valorile medii ale hemoglobinei şi hematocritului au fost de 10,91 g/dl si respectiv 33%. Tratamentul a fost non-operator pentru 84,4%, şi operator pentru 15,6%. La externare 56,2% dintre pacienți erau vindecați, iar 43,8% ameliorați.
Concluzii: Cu o echipă performantă multidisciplinară de chirurgi, terapişti, şi radiologi, managementul non-operator la pacienții

pediatrici cu traumatisme închise hepatice şi splenice este eficient şi sigur, depinde mai degrabă de stabilitatea hemodinamică decât de extensia leziunilor, reduce perioada de spitalizare şi administrarea de hemostatice şi transfuzii.

Cuvinte cheie: copii, traumatism abdominal închis, traumatism hepatic, traumatism splenic, management non-operator

Abstract

Aim: The aim of the present study is to assess some characteristics of blunt hepatic and splenic injuries in children, the non-operative management (NOM) procedures and efficiency, over a 5-year period in a tertiary hospital for children.
Materials and Methods: We conducted a retrospective study on 32 patients with blunt liver and/or spleen injuries. Age, gender, mechanism of injury, hemoglobin and hematocrit levels, lenght of stay and bedrest, imaging diagnosis, hemostatics and transfusions, treatment, and discharge status were evaluated.
Results: 58% of patients were males. Mean age was 10.7 years. The main mechanism of injury was motor vehicle accident. Ultrasound (US) and Computed Tomography (CT) found 56.2% patients with spleen injury and 43.8% with liver injuries. On US the most frequent injuries were lacerations, and on CT were splenic-grade III and hepatic-grade II. 84.4% of patients were hospitalized in Intensive Care Unit and 15.6% in the surgical unit. The mean hemoglobin and hematocrit were 10.91g/l and 33%, respectively.The treatment was non-operative for 84.4%, and operative for 15.6%. When discharged, 56.2% of patients were cured and 43.8% were improved.
Conclusion: With a performing multidisciplinary team of surgeons, intensive care therapists and radiologists, NOM in pediatric patients with blunt liver and spleen injuries is safe and effective, may be conducted depending on the hemodynamic stability rather than the lesions' extension, and reduces the ICU lenght of stay, as well as the need for hemostatics and transfusion.

Key words: children, blunt abdominal trauma, liver injury, spleen injury, non-operative management

Introduction

Pediatric patient has a great life expectancy, and his quality of life may be diminished by invasive investigative techniques, as well as by a partial or total organ excision. Extensive scars may also have an important psychological impact, which recommends, even more in children, the use of minimally invasive techniques or the non-operative management (NOM). In the last 40 years NOM became the first intention treatment for blunt liver and spleen trauma in children (1).

In polytrauma patients, the incidence of solid abdominal organs injuries is 30%, the most affected being the spleen and the liver (2). In hemodynamically unstable patients, focused abdominal sonography for trauma (FAST) is the first intension imaging method, showing the blood presence in the abdominal cavity (3,4). There are 3 tipes of solid organ lesions on a complete abdominal ultrasound (US): contusion (disorganized hypoechoic structure, capsular integrity), subcapsular hematoma, and parenchymal laceration (5). The minimum hemoperitoneum detection threshold remains a controversial topic. Tiling et al showed that 30 ml is the minimal fluid quantity that can be found on US, a thin anechoic stripe in Morrison's pouch represents

250 ml of free fluid, while 0.5 cm or 1 cm wide stripes reflect 500 ml and 1 L, respectively, of free fluid (6).

CT scan is considered the gold standard method in assesing hemodynamically stable pediatric patients with abdominal trauma (7). However, it has some disadvantages: it does not make the diagnosis of cavitary organs injuries; the need of contrast substances with associated nephrotoxicity and alergic reactions; high grade of X-ray iradiation that must be avoided in pediatric patients (8). The American Association for Surgery of Trauma (AAST) classified the abdominalinjuries in 5 grades for the spleen and 6 grades for the liver (9).

NOM in blunt liver and spleen pediatric trauma became possible due to the technological progress of imaging investigations and intensive care methods. It has a success rate up to 90%, and a lower complication rate comparing to the operative management (OM) (10). The main complications of NOM are pseudoaneurysm with secondary haemorrhage, abscess or biloma (3). Dates from the medical literature show that NOM failure in children occurs in the first 6-12 hours after the trauma. Basically, NOM consists in fluids and hemostatic administration, bedrest, and serial laboratory assessment of hemoglobin (Hb) and hematocrit (Ht); if the bleeding is active, the patient may be initially transfused before OM to be required (11). Most of recent studies recommend that NOM must be conducted based on hemodynamical status rather than the AAST injury-grade (12).

The aim of the present study is to asses some characteristics of blunt hepatic and splenic injuries in children, the NOM procedures and efficiency, over a 5-year period in a tertiary hospital for children.

Materials and Methods

We conducted a 5-year retrospective study on 32 patients with blunt liver and/or spleen injuries treated in the Sf. Ioan Clinical Emergency Hospital for Children from Galati, from 2017 to 2021. Data were colected from the medical charts and from the electronic data base through the ATLAS application. We searched the following aspects: year, age, gender, origin environment, mechanism of injury, Hb and Ht levels, lenght of stay (LOS), lenght of bedrest, hemostatic treatment, transfusions, imaging diagnosis, treatment, and discharge status. All data were merged into the IBM Statistics SPSS, V26 program. Chi square tests were performed for validation of significant statistic differences between variables; the statistical significance threshold (p) was set at 0.05. Descriptive statistics was performed for finding particularities of included scalar variables.

The inclusion criteria were: age under 18 years, hepatic and/or liver trauma on US or CT. The exclusion criteria were: patients with US diagnosis of hepatic and/or liver trauma in ICU, but with normal organ appearance on further imaging investigation (n=7), patients transferred to another hospital (1 patient who was on vacantion but lived in Bucharest) (*Fig. 1*).

In pediatric patients, hemodynamic stability is considered a systolic blood pressure of 90 mmHg plus twice the child's age in years. An acceptable hemodynamic status in children is considered a positive response to fluid resuscitation: 2-3 boluses of 20 mL/kg of crystalloid replacement (before blood replacement) should lead to heart rate decrease, and increase in blood pressure. (Coccolini F, Moore EE, Kluger Y, Biffl W, Leppaniemi A, Matsumura Y, Kim F, Peitzman AB, Fraga GP, Sartelli M, Ansaloni L, Augustin G, Kirkpatrick A, Abu-Zidan F, Wani I, Weber D, Pikoulis E, Larrea M, Arvieux C, Manchev V, Reva V, Coimbra R, Khokha V, Mefire AC, Ordonez C, Chiarugi M, Machado F, Sakakushev B, Matsumoto J, Maier R, di Carlo I, Catena F; WSES-AAST Expert Panel. Kidney and uro-trauma: WSES-AAST guidelines. World J Emerg Surg. 2019 Dec 2;14:54. doi: 10.1186/s13017-019-0274-x.) In our hospital, hemodynamic instability is defined as systolic blood pressure (SBP) below 90 mmHg and heart rate (HR) above 120/min.

The refference levels of our laboratory are 11-14.5 g/dL for Hb, and 33-43% for Ht.

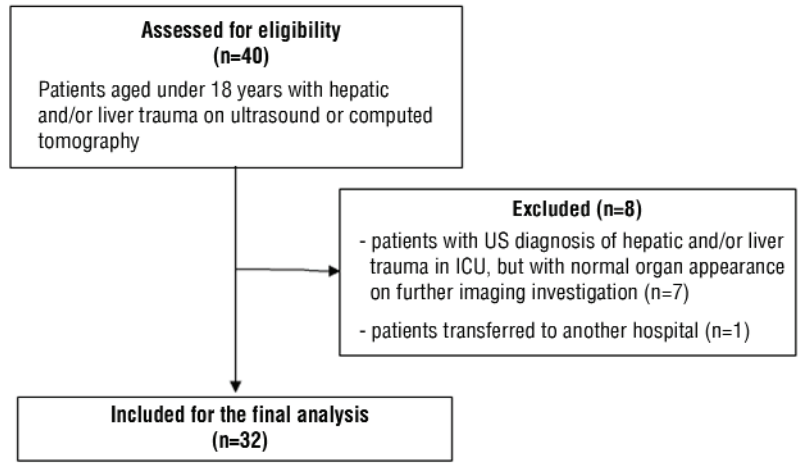

Figure 1. STROBE inclusion flowchart

Bedrest was defined as initial supine position with minimal lower limbs mobilisation, followed by a semi-supine position (30°-40° torso flexion). When liver and spleen injuries were associated, we included in the statistical analysis the more extensive lesion.

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Sf. Ioan Clinical Emergency Hospital for Children of Galati, Romania (Protocol No. 13404 approved on June 6th 2023). An informed consent for using personal unidentifiable data for publication was signed at admission by all patients' parents.

Results

The present study included 32 patients, for a period of 5 years. The distribution by year of presentation was as follow: 8 patients (25%) in 2017, 5 patients in 2018 (15.6), 11 patients (34.3%) in 2019, 3 patients (9.3%) in 2020, 5 patients (15.6%) in 2021. Regarding the gender, 18 (56.2%) were males and 14 (43.8%) females, with the same distribution for rural and urban areas, respectively. The mean age was 10.7 years (range 1-17).

There were 7 mechanisms of injury: motor vehicle accident (n=11; 34.3%), physical aggression (n=10; 31.2%), fall from a height (4; 12.5%), fall on flat ground (3; 9.3%), bicycle accident (2; 6.2%), horse bite and horse hoof kick (1; 3.1% each) (*Table 1*).

In Emergency Care Unit (ECU), 5 patients (15.6%) were hemodynamically unstable (HR>100 bpm, SBP<90 mmHg), with mean Hb = 7.55 g/dl, and mean Ht = 24.2%.

The initial imaging investigations were performed in the Department of Radiology and diagnosed 16 patients with isolated splenic injuries, 13 with isolated hepatic injuries and 3 with concomitant injuries. 72 % of patients were found to have hemoperitoneum, and 21.7% of those had a large amount of free peritoneal fluid. In total, 31 patients (96.8%) had abdomino-pelvic US, and 15 patients (46,8%) had abdomino-pelvic CT. The process of imaging diagnosis was complex. In ECU 31 patients had US and one had CT. Of the 31 US, 3 showed normal abdominal aspect, but because there were evident differences between the imaging features and the clinical/paraclinical patient's status, it was required a CT scan, which showed 3 splenic injuries (1 patient with grade II, and 2 patients with grade III). In addition, CT completed the US diagnosis for another 11 patients, and in 6 cases the CT lesion was more extensive than on US. Briefly, of 31 US, 3 (9.6%) were normal and 6 (19.3%) underdiagnosed the injury. Finally, US detected 31 lesions: 15 (48.3%) splenic and 16 (51.7%) hepatic; the most frequent injuries were

Table 1. Patients' demographic and the main variables of the study

Variables		Spleen injury	Liver injury	Total study group	Chi square test (p)
Number of patients (n; %)		18 (56.2%)	14(43.8%)	32 (100%)	
Mean age (years, range)		11.2 (6-17)	10 (1-17)	10.8 (1-17)	
Environment (n;%)	Rural	7 (38.8%)	11(78.5%)	18 (56.2%)	0.51
	Urban	11 (61.2%)	3 (21.5%)	14 (43.8%)	
Gender (n;%)	Male	11 (61.2%)	7 (50%)	18 (56.2%)	0.341
	Female	7 (38.8%)	7 (50%)	14 (43.8%)	
Mechanism of injury (n;%)	Motor vehicle accident	5 (27.7%)	6 (42.8%)	11 (34.3%)	0.534
	Physical aggression	8 (44.4%)	2 (14.2%)	10 (31.2%)	
	Fall from a height	2 (11.1%)	2 (14.2%)	4 (12.5%)	
	Fall on flat ground	1 (5.5%)	2 (14.2%)	3 (9.3%)	
	Bicycle accident	1 (5.5%)	1 (7.1%)	2 (6.2%)	
	Horse bite	1 (5.5%)	0	1 (3.1%)	
	Horse hoof kick	0	1 (7.1%)	1 (3.1%)	
Hemodynamic instability (n)		4 (22.2%)	1 (7.1%)	5 (15.6%)	0.307
Admission (n; %)	Surgical unit	2 (11,1%)	3 (21.4%)	5 (15.6%)	0.604
	Intensive Care Unit	16 (88.9%)	11(78.6%)	27 (84.4%)	
Overall mean LOS (days, range)		12 (4-25)	13.5(1-42)	12.7(1-42)	
Mean LOS in ICU (days, range)		7.8 (6-25)	7.6(1-27)	7.7 (1-27)	
Mean LOS in surgical unit (days, range)		4.5 (4-5)	4 (2-6)	4.2 (2-6)	
Mean bedrest (days, range)		3.1(1-5)	3 (1-7)	3 (1-7)	
Mean Hemoglobin (g/dl, range)		10.48 (6.9-14.5)	11.47 (8.7-15.2)	10.91 (6.9-15.2)	
Mean Hematocrit (%, range)		31.9 (21-43.5)	34.5 (26.3-44)	33 (21-44)	
Mean days hemostatics (days, range)		6 (1-15)	6.3 (1-7)	6.1 (1-15)	
Transfusion (n;%)	Operative management	4 (22.2%)	0	4 (12.5%)	0.236
	Non-operative management	1 (5.5%)	2 (14.2%)	3 (9.3%)	
Management	Non-operative	13 (72.2%)	14 (100%)	27 (84.3%)	0.044
	Operative	5 (27.8%)	0	5 (15.7%)	
Discharge status (n)	Improved	5 (27.8%)	9 (64.2%)	14 (43.8%)	
	Cured	13 (72.2%)	5 (35.8%)	18 (56.2%)	

lacerations, 8 (25.8%) splenic and 9 (29%) hepatic. CT detected 18 lesions: 8 (44.4%) splenic, and 10 (55.6%) hepatic; the most frequent were splenic-grade III and hepatic-grade II, 5 of each (27.7%) (*Table 2*).

Because 3 patients had both organs injured, for an accurate statistical analysis we decided to take into consideration the most extensive injury. Consequently, further analysis is achieved on 18 (56.2%) patients with spleen injury and 14(43.8%) with liver injuries (*Figs. 2, 3, 4, 5*).

Table 2. Types of injuries found on imaging investigations

Variables		Ultrasound (n)						Computed Tomograph (n)					
		Spleen injuries			Liver injuries			Spleen injuries			Liver injuries		
		C	SH	L	C	SH	L	I	II	III	I	II	III
Year	2017	2	-	3	3	-	1	1	-	1	1	-	-
	2018	-	-	3	-	-	2	-	-	2	-	-	-
	2019	3	1	2	1	1	1	-	2	1	-	-	1
	2020	1	-	-	1	-	2	-	-	1	-	2	1
	2021	-	-	-	-	1	3	-	-	-	-	3	2
Total (n)	US :31	6	1	8	5	2	9						
	CT:18							1	2	5	1	5	4

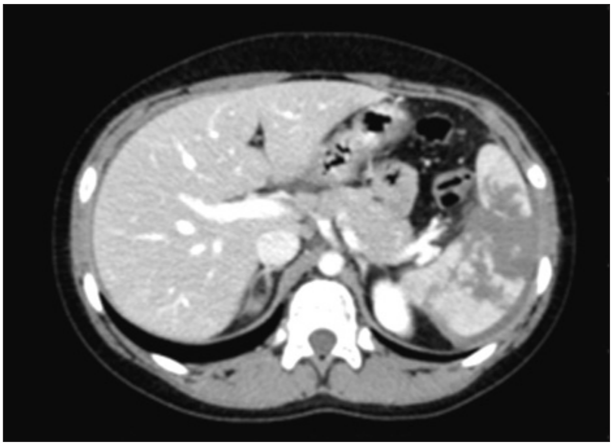

Figure 2. Axial postcontrast CT: AAST grade III spleen, NOM

Figure 3. Coronal postcontrast CT: AAST grade III spleen, NOM

All patients were hospitalized, 27 (84.4%) in the Intensive Care Unit (ICU) and 5 (15.6%) in the surgical unit. We compared some variables between the surgical unit group and the ICU group (*Table 3*). The mean overall LOS was 12.7 days (range 1-42), for ICU it was 7.7 days (range 1-27), and for surgical unit it was 4.2 days (range 2-6), without significant statistically differences (sig = 0.604). The overall mean bedrest period was 3 days (range 1-7), for ICU it was 3.4 days (range 1-7), and for surgical unit was 1.4 (range 1-3). Hemostatics and transfusion were administered only in the ICU group. The mean Hb and Ht for the surgical unit group were 12.6 g/dl and 39.4%, in contrast to ICU group where the levels were 10.5 g/dl and 31.8%. Hb and Ht levels under the normal ranges were found only in the ICU group, in proportion of 62.9% both.

The treatment was non-operative for 27 (84.4%), and operative for 5 (15.6%). We compared the two subgroups (*Table 4*). Both overall and ICU LOS were shorter for the NOM group, but the bedrest period was similar (3 days). All patients in the OM group required hemostatics, comparing to 81.4% in the NOM group. The need for transfusion was significantly higher in OM group (80% versus 11.1%)(p=0.000) and the levels of Hb and Ht were lower (8.42 g/dl and 25.8% versus 11.38 g/dl and 34.4%). All patient in the OM group had Hb and Ht levels under the normal ranges, comparing to 44.4% in NOM group.

Figure 4. Axial postcontrast CT: AAST grade III liver, NOM

Figure 5. Axial postcontrast CT: AAST grade III spleen (laceration and subcapsular hematoma), NOM

Table 3. Comparative findings between patients admitted on surgical unit and patients admitted on ICU

Variables		Surgical unit	Intensive Care Unit	(p)
Number of patients (n, %)		5 (15.6%)	27 (84.4%)	
Lenght of stay (days) (mean, range)		4.2 (2-6)	7.7 (1-27)	
Hemostatics	% patients	0 (0%)	100 (100%)	
	mean period (n, range)	0	6.1 (1-15)	
Bedrest (days) (mean, range)		1.4 (1-3)	3.4 (1-7)	
Transfusion (n, %)		0 (0%)	7 (25.9%)	0.558
Mean Hemoglobin (g/dl)		12.6	10.5	
Hemoglobin <11 g/dl (n, %)		0 (0%)	17 (62.9%)	
Mean Hematocrit %)		39.4	31.8	
Hematocrit <33% (n, %)		0 (0%)	17 (62.9%)	
Hemodynamic instability (n, %)		0 (0%)	5 (18.5%)	0.242

Table 4. Comparative findings between non-operative management and operative management

Variables		Non-operative management	Operative management	Chi square test (p)
Number of patients (n, %)		27 (84.4%)	5 (15.6%)	
Overall LOS (days) (mean, range)		12.2 (1-42)	15.2 (12-20)	
LOS in ICU (days) (mean, range)		6.1 (1-27)	8.6 (6-18)	
Hemostatics	n, % patients	22 (81.4%)	5 (100%)	
	mean period (n, range)	6.7 (1-15)	3.6 (1-6)	
Bedrest (days) (mean, range)		3 (1-7)	3.4 (3-5)	
Transfusion (n, %) 3 (11.1%)		4 (80%)	0.000	
Mean Hemoglobin (g/dl)		11.38	8.42	
Hemoglobin <11 g/dl (n, %)		12 (44.4%)	5 (100%)	
Mean Hematocrit (%)		34.4	25.8	
Hematocrit <33% (n, %)		12 (44.4%)	5 (100%)	
Hemodynamic instability (n, %)		2 (7.4%)	3 (60%)	0.03

Hemodynamically instable patients were 60% in the OM group and 7.4% in NOM group (p=0.03). At the discharge moment, 14 (43.8%) patients were improved and 18 (56.2%) were cured.

Discussion

The present study was conducted in a single pediatric hospital over a 5 year period. We retrospectively evaluated 32 patients with blunt liver and/or spleen trauma. The higher number of patients was registered in 2019, with a slight predominance of the male gender and of the rural area. The mean age of the patients was 10.8 years, which is consistent with the study of Koyama et al (13). The youngest patient in our study had 1 year and was diagnosed as Silverman syndrome. First described in 1962, the battered or abused child syndrome (Silverman) is characterised by multiple injuries and lethal potential (14).

The main mechanisms of injury were motor vehicle accidents (34.3%) closely followed by physical aggression (31.2%), in contrast to most similar studies, where the second most common injury mechanism was fall from height (15,16).

Regularly, all trauma patient admitted to our ECU have their vital functions evaluated, and a thorough physical examination performed, in order to proceed with complementary investigations. Most of these patients, even with a normal physical examination, benefit from abdominal ultrasoud as an initial imaging investigation. Usually, the patient is transported to the imaging department for a complete abdomino-pelvic US, but in case of major trauma, when patients are in need of multiple life-saving manoevers, FAST is performed in the trauma room. None of the patients included in our study required FAST, although on admission in ECU 15.6 % (n=5) were hemodynamically unstable, with

HR >100 bpm, SBP<90 mmHg, as well as Hb and Ht levels under the normal ranges of our laboratory. According to the modern protocols, all 5 patients from this subgroup received in ECU fluid resuscitation with intravenous crystalloid fluids (a 20 mL/kg bolus of warmed lactated Ringer's or normal saline); subsequently, they temporarily became stable, allowing us to perform US or CT, which showed grade III splenic injury for 60% (n=3). Obviously, they were admitted to ICU; because SBP started to drop again, they received one more crystalloid bolus followed by transfusion (15 mL/kg of warmed packed red blood cells). Nevertheless, 60% (n=3) required splenectomy.

It is well known that hypovolemia in children is very well compensated, and hypotension occurrs when 40%-45% of circulating blood is lost (17). The first reaction to hemorrhagic shock in pediatric patients is tachycardia, but one must be aware of the HR variability depending on age, and on the emotional stress (18).

Imaging investigations in ECU were US and CT, which found 13 patients with isolated hepatic injuries, 16 with isolated splenic injuries and 3 with both organs injured. US was performed in ECU for 31 patients. In one case, an adolescent patient fallen from a height, CT was used for the initial imaging assesment. The injuries discovered on US were 48.3% spleen lesions and 51.7% liver lesions (Table 2); the most frequent injury was laceration both for spleen (mean lenght of laceration: 3.6 cm) and liver (mean lenght of laceration: 4.2 cm).

The japanese and american guidelines for initial trauma assesment recommend the whole-body CT (from the crane to the pelvis) (19). In our hospital, this extensive and expensive investigation is reserved for the polytrauma cases (associated cranial, thoracic, abdominal, skeletal injuries), otherwise selective CT is preferred. Consequently, we performed abdomino-pelvic CT scans in 46.8% (n=15) of patients. Unlike our study, the CT rate of use was 63% for Basaran et al (15), and 86% for Fernandes et al (16). There were 3 patients with normal abdominal aspect on US, but because of abnormal clinical and paraclinical findings, CT scan was required, showing spleen injury grade II or III. We can conclude that in our study US had a 90.4% sensitivity in detecting spleen injuries, higher than 68% found by Basaran et al (15). On the other hand, in 19.3% of patients, the lesion was more extensive on CT than on US, 83.3% of these underdiagnosed cases being also spleen injuries. The most frequent lesions on CT were AAST - grade III for spleen and AAST - grade II for liver. These results are compatible with the literature (20,21), while Divya et al found liver injuries grade IV to be the most frequent (22). We noted that 86.6% of CT scans were performed in the last 3 years of study.

Coroborating the findings of US and CT, and considering the most extensive of the lesions when they were associated, there were 18 (56.2%) patients with splenic injuries and 14 (43.8%) with hepatic injuries, in contrast to many recent studies that found a higher incidence for liver injuries (9,11,15,22).

All 32 patients were hospitalized, 84.4% of them being admitted to ICU. Although American Pediatric Surgical Association (APSA) guidelines indicates admission to ICU only for patients with abnormal vital signs after ECU resuscitation (22), our team of pediatric surgeons regularly hospitalize all liver or spleen trauma. However, grade I-AAST injuries (or the US correspondent - contusion), regardless of the injured organ, are usually hospitalized on the surgical unit, while grade II-V are admitted directly to ICU, regardless of SBP or Hb levels. 2023 APSA guidelines suggest that patients with liver or spleen blunt trauma should be hospitalized for a period represented by the injury grade plus one, and only patients with injuries grade IV-V should benefit of one day in ICU. Our study reported a longer LOS, but regarding the bedrest period, we proceeded according to APSA recommendation, maintaining this restriction until the the patient is hemodynamic stable (23). For all 32 patients included in our study, the mean overall LOS was 12.7

days, and the mean time for bedrest was 3 days. The mean LOS in ICU was 7.7 days which means that patients spent in ICU 60.6% of the total hospitalization time. The study conducted by Grootenhaar et al in Netherland (10) reported a similar total LOS (10.2 days), with a mean of 5 bedrest days, but their length of ICU stay was half of ours (3.5 days). However two other studies from Austria found a 14 days mean LOS, longer than in our study (9,11).

In the present study, 15.6% of patients were admitted from the beginning to the surgical unit. Comparing to those admitted to ICU, we noted: normal levels of Hb and Ht, no need for hemostatics or transfusion, as well as shorter LOS and bedrest (Table 3). 60% of the US injuries were contusions, the most serious injury being one hepatic laceration (4 cm lenght). In contrast, 84.4% of patients were initially admitted to ICU, their mean Hb and Ht levels being under the normal ranges of our laboratory.

In our study, 84.3% of patients had been treated conservatively, which is similar to many other studies (9,10,11,16). We need to emphasize that in the first 24-48 hours which are critical, besides permanent monitoring HR and SBP we assess Hb and Ht levels every six hours; when the patient has 24-48 hours of hemodynamic and paraclinic stability, monitoring is reduced to 12-hours or 24-hours interval, until Hb and Ht are at the inferior level of the normal laboratory ranges. All ICU pacients received hemostatics and 25.9% needed transfusion. By comparison, a study from Netherland, found a higher mean level of hemoglobin 11.36 g/dL, which may explain their shorter LOS on ICU (10), and in the study of Basaran et al, the mean hemoglobin was even higher, 13.1 g/ dl, with hematocrit 40.1% (15).

NOM consisted in fluid resuscitation, analgetics (perphalgan, midazolam, pethidine), anti-inflammatory drugs (dexamethasone, ibuprophen), prophylactic antibiotics (third generation cephalosporin), hemostatic therapy and transfusions. In our hospital, in contrast to grade II-V lesions, for grade I lesions the use of hemostatics is not mandatory. The usual hemostatic doses are: intravenous adrenostasine 1,5 mg every 8 hours and etamsylate 125 mg every 8 hours (half of the adult dose), or tranexamic acid (15 mg/kg).

Our therapists consider that transfusion for trauma patients become mandatory when Hb < 8 g/dl or Ht < 25%. The most used blood product are red blood cells (15 ml/kg), while platelet or fresh frozen plasma are reserved for patients with severe hemorrhagic shock (Hb<5g/dl). Transfusion was necessary for 11.1% (n=7) of our conservativelly treated patiens, for a mean Hb level of 8.6 g/dl, all cases being grade III injuries; one patient had associated grade III spleen and grade II liver. We noted that 71.5% (n=5) of transfused patients had splenic injuries. Although APSA guidelines recommend transfusion in only 5% of patients (22), and the last expert consensus for transfusion in critically ill children consider transfusion for a hemoglobin concentration between 5–7 g/dl (24), in practice, the percentage of transfusions and the threshold of hemoglobin is similar to our study (10,25).

Operative management was required for 15.6% (n=5) of patients, the sole techique being complete open splenectomy. In accordance to all modern guides, the decision to operate was made when hemodynamic instability persisted despite of appropriate resuscitation measures (fluids, hemostatics, transfusion) (22,23,26). All patients were operated within the first 6 hours from admission, and all surgeries were performed for grade III of injury. We emphasize that in the last 3 years all patients (n=18) were treated with NOM. Comparing the 2 tipes of treatment, we observed some quantitative differences: the patients treated non-operatively had a shorter LOS and a significantly reduced need for transfusion (seven times less). On the other hand, there was a statistical correlation between hemodynamic instability (p=0.03), the need for transfusion and the necessity of surgical treatment (p=0.000) (*Table 4*). We emphasize that 40% of the operated patients had SBP>90 mmHg at admission in ICU (due to a prompt fluid resuscitation in ECU), but because the hemorrhage continued despite hemostatics and transfusion, the OM became mandatory.

All patients included in the study had an uneventful evolution, without complications. On discharge, the patient must be hemodynamically stable, with a normal diet and without abdominal pain, as APSA guidelines recommend (23). The patients' discharge status was cured for 43,75% (without lesion on US), and improved for 56.25% of patients (diminished lesion). In contrast to APSA guidelines (23), which suggest that imaging follow-up is unnecessary both pre- and post-discharge, our surgeons preffer to have a proper imaging surveillance of all injuries, in addition to measuring Hb and Ht values. On discharge, patients were recommended 1-3 weeks of physical or school activity restriction, depending on the grade of injury, comparing to APSA guidelines which consider that injury grade plus 2 weeks is a safe period (23); apparently it is a longer period than ours, but our patients spent more time in the hospital.

The study has some limitations. First of all, the group of patients is small, and the study was conducted in a single center, so the results might not be generalisable. Secondly, the highest grade of injury was AAST-III. Thirdly, without a reported grade on CT for all the patients, we couldn't compare our results with all the APSA guidelines. On the other hand, we noted that those recommendations are requested and appliable on the North-American continent, Europe missing an unitary protocol for liver and spleen trauma in children (22). Our opinion is that in our country, without a national protocol on this pathology, applying all APSA suggestions may have catastrophic consequences both on patients and physicians. Nevertheless, this study reflects our experience, providing an image of the current management of pediatric liver and spleen blunt injuries.

Conclusion

This study confirms that in pediatric patients with liver and spleen blunt injuries, the treatment is conducted depending on the hemodynamic stability rather than the computed tomograph grade of the injured organ. NOM seems to be safe and effective, reducing the need for hemostatics and transfusion as well as the Intensive Care Unit lenght of stay, provided there is a performing multidisciplinary team of surgeons, intensive care therapists and radiologists.

Authors' Contribution

I.A.S., D.-M.D. conception and design of the manuscript. I.A.S., C.V.-C., L.B., H.M. data extraction, wrote the paper. C.B., R.-E.B. performed the analysis. I.A.S., L.B. supervised, reviewed and edited the manuscript, verified the methodology. All authors reviewed the results and approved the final version of the manuscript.

Conflict of Interest

The authors have no conflicts of interest. The study had no funding or financial assistance.

Ethical Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Sf. Ioan Clinical Emergency Hospital for Children of Galati, Romania (Protocol No. 13404 approved on June 6th 2023). An informed consent for using personal unidentifible data for publication was signed at admission by all patients' parents.

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