A Standardized Approach for Spleen Trauma in the Children

Çocuklardaki Dalak Travmalarında Standardize Bir Yaklaşım

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ABSTRACT

Aim: The aim of this study is to evaluate the results of pediatric blunt spleen trauma patients who were treated with a standard fluid protocol.
Patients and Method: Children who were treated in a university hospital for blunt spleen trauma between 2012 and 2015 were included. Age, gender, mechanism of the injury, spleen injury scale, concomitant injuries, hemoglobin levels, thrombocytopenia and thrombocytosis, administration of blood and blood products, and hospital stay duration and results were evaluated. The fluid requirements of the stable children were calculated according to Holliday-Segar equation. The fluid intake of the children was adjusted so that the urine output was 1 ml/kg/h.
Results: Totally 28 children who were at the age of 3-18 years were evaluated. Injury grade (G) was G1 in 3 patients, G2 in 12 patients, G3 in 10 patients, G4 in 2 patients, and G5 in 1 patient. There were no side effects related to the fluid protocol and the monitoring of the urinary output was helpful. Grade 5 patient needed an immediate splenectomy. Thrombocytosis was developed in four patients during the hospitalization and it suggested an impaired clearance of spleen in Grade 4 patients. Re-bleeding developed in one G3 patient after discharge. No mortality was observed.
Conclusion: Our management protocol was successfully applied and spleen loss was observed only in a case of grade 5 injury. Adjusting the fluid volume according to the urinary output prevented volume overload and re-bleeding. Thrombocytosis may occur after severe splenic trauma and it should be carefully followed up.

Key Words: Spleen, trauma, child, thrombocytosis

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ÖZET

Amaç: Bu çalışmanın amacı, künt dalak travması olan ve standart bir sıvı protokolü ile izlenen pediyatrik hastaların sonuçlarını değerlendirmektir.
Hastalar ve yöntem: Bir üniversite hastanesinde 2012-2015 yılları arasında künt dalak travması nedeniyle tedavi edilen çocuklar çalışmaya dahil edildi. Yaş, cins, yaralanma mekanizması, dalak yaralanma skalası, eşlik eden diğer yaralanmalar, hemoglobin düzeyleri, trombositopeni ve trombositoz, verilen kan ve kan ürünleri, hastanede kalma süresi ve sonuçlar değerlendirildi. Stabil çocuklarda sıvı gereksinimleri Holliday-Segar denklemine göre hesaplandı. İdame sıvı, idrar çıkışı 1 ml/kg/sa olacak şekilde ayarlandı.
Bulgular: Yaşları 3-18 yaş arasında toplam 28 çocuk çalışmaya dahil edildi. Yaralanma derecesi (G) 3 hastada G1, 12'sinde G2, 10'unda G3, ikisinde G4 ve bir hastada G5 idi. Sıvı protokolüne ait yan etki gözlenmedi. İdrar çıkışının monitorizasyonu yararlı bulundu. G5 hastaya hemen splenektomi yapıldı. Hastane yatış süresi içinde 4 hastada trombositoz ortaya çıktı, bunlardan ikisi, dalak klirensinin azaldığı düşünülen G4 yaralanması olan hastalardı. Bir G3 hastada taburculuk sonrasında kanama tekrarladı. Seride mortalite olmadı.
Sonuç: Yaklaşım protokolümüz başarıyla uygulandı ve sadece G5 hastada dalak kaybı oldu. Sıvı gereksinimlerinin idrar çıkışına göre ayarlanması, sıvı yüklenmesini ve kanamanın tekrar başlamasını önledi. Ağır dalak yaralanmalarından sonra trombositoz ortaya çıkabilir ve dikkatle izlenmeyi gerektirir.

Anahtar Sözcükler: Dalak, travma, çocuk, trombositoz

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INTRODUCTION

Spleen injuries are the most frequently observed and life-threatening intra-abdominal injuries in children after a blunt trauma. The general approach to spleen trauma in children is conservative. Non-operative management (NOM) protocols (such as intensive care unit (ICU) stay, hospital stay, and imaging and activity restriction depending on the grade of the injury) have been proposed for spleen and liver injuries in children (1, 2). Criteria for NOM protocol selection are mainly the absence of peritonitis signs and having a hemodynamically stable child. The prognosis of a spleen injury mainly depends on the presence of associated injuries.

There is no standard transfusion protocol which shows when and how much blood should be transfused to pediatric patients (3, 4). The recommended fluid amount for hypovolemia due to bleeding in a trauma patient is initially 20 mL/kg and it can be given up to 40-60 mL/kg. If the child still has low blood pressure and shows the signs of hypovolemic shock, transfusion is recommended (5). Surgery decision can usually be taken within 24 hours after the trauma. If the child is stable and selected for NOM protocol, he/she is taken to the ICU or children's ward depending on the severity of the injuries. The rules of follow-up such as control of hemoglobin (Hb) levels (6) and length of stay (7) are still debatable. Follow-up depending on the physiology and hemodynamic status of the patient is recommended.

There is no controlled study conducted on spleen functions of children that suffered from spleen trauma. It is well known that thrombocytosis occurs after splenectomy (8), and thrombocytosis is also one of the indicators for hyposplenism (9).

In this study, pediatric blunt spleena injury patients who were selected for NOM in a single centre in which a standard fluid protocol was used were retrospectively evaluated for spleen preservation and spleen function.

PATIENTS and METHOD

Children who were treated in a university hospital for blunt spleen trauma between 2012 and 2015 were included in the study after the approval of Local Human Ethics Committee of Kutahya Dumlupınar University (2011-KAEK-2). Age, gender, mechanism of injury, spleen injury scale (Table 1) (10), concomitant injuries, hemoglobin levels, thrombocytopenia and thrombocytosis, administration of blood and blood products, and hospital stay duration and results were evaluated.

Table 1. Spleen injury scale (1994 revision) (10)

Grade*	Injury type	Injury description
I	Hematoma	Subcapsular, <10 percent surface area
	Laceration	Capsular tear, <1 cm parenchymal depth
II	Hematoma	Subcapsular, 10-50 percent surface area; intraparenchymal, <5 cm in diameter
	Laceration	1-3 cm parenchymal depth which does not involve a trabecular vessel
III	Hematoma	Subcapsular, >50 percent surface area or expanding; ruptured subcapsular or parenchymal hematoma
		Intraparenchymal hematoma >5 cm or expanding
	Laceration	>3 cm parenchymal depth or involving trabecular vessels
IV	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (>25 percent of spleen)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury which devascularizes spleen

Spleen injury was graded by using computerized tomography or Doppler ultrasonography.

Standard fluid protocol of the department adjusts the fluid intake according to the urinary output which is set to 1 ml/kg/h after the initial resuscitation unless there is a contraindication in stable patients (Table 2).

Table 2. Non-operative blunt liver-spleen injury management fluid protocol

1. Exclusion criteria: Severe head trauma, renal trauma, peritonitis, unstable patient.
2. Observe G4, G5 patients and patients with serious additional injuries in the intensive care unit.
3. Fluid administration: 0.09% NaCl, calculated using Holliday-Segar equation. If the patient continues to be stable, continue with Isolyte P.
4. Monitorization:
    a) Follow blood pressure, keep it between normal levels appropriate for the age of the child.
    b) Follow urinary output hourly, keep it around 1 mL/h/kg. Insert urinary catheter to the patients that are in the intensive care unit.
5. Appropriate pain medication
6. Hemogram every 6 hours until stable, evaluate hemoglobin level and thrombocyte count
7. If the hemogram is stable after 3 consecutive measurements, one more hemogram 24 hours later will be sufficient in low grade injuries. Consider hemogram control for at least 3 days in G4 injuries even if the hemoglobin is stable.
8. Adjust the fluid administration at 8 hourly intervals if:
    a) Urinary output is higher or lower than 1 mL/h/kg
    b) Blood pressure is higher or lower than the normal limits for the age of the child.
9. If the hemoglobin level falls below 8 g/dL, consider giving erythrocyte infusion and fresh frozen plasma and thrombocyte suspension.
10. If thrombocyte level is rising, consider spleen hypofunction.
11. If there is thrombocytopenia or high INR, consider giving fresh frozen plasma.
12. If the child received >40 mL/kg ES within 24 hours and still unstable, consider surgery.
13. If the child is stable and there is no contraindication for oral nutrition, start feeding orally.
14. If the child is stable and can be fed orally, consider control US after grade plus 1 day.

Initial calculation was done depending on the weight of the patient by using the Holliday-Segar equation (**11**), which is a common formula used for the calculation of the fluid requirements of children. Colloids were not used and 3% NaCl-3.33% dextrose was the preferred IV solution. During the monitoring, the fluid administration was adjusted depending on the urinary output in case the blood pressure and pulse values were stable. Blood pressure, pulse, and oxygenation were closely monitored. Careful pain management was also done. It was aimed to keep the blood pressure levels within the normal range according to the patient's age and maintain the adequate perfusion which was monitored by the urinary output. High or low blood pressures as well as high or low urinary output were tried to be avoided. G4 patients and patients with additional injuries who needed close monitoring were observed in the intensive care unit. The fluid protocol was applied unless there was any other contraindication related to the concomitant injuries of the child and until the patient can be fed orally. Patients who did not receive this protocol because they were treated by other departments due to additional traumas were not included in the study.

Hemograms were obtained every 6 hours in the first 24 hours depending on the hemodynamic status of the patient. Hemoglobin and thrombocyte levels were followed until they were stable. Erythrocyte suspension (ES) was administered if the Hb level was lower than 8 g/dL. Fresh frozen plasma (FFP) was administered to patients if there was a thrombocytopenia or the coagulation test results were abnormal.

Patients were asked to come for follow-up after discharge. Repeat ultrasonography and hemograms were obtained in case results were not normal at the discharge. Follow-ups were done weekly until the blood tests were normal and the spleen was normal with ultrasonograpy.

RESULTS

Totally 28 children who were between the ages of 3-18 years (mean 10.16 years; 21 male and 7 female) were included in the study. Injuries were because of falls (10), pedestrian injuries (5), car accidents (6), bicycle/motorcycle injuries (3), assault (1), and crush injuries (3) (Table 3).

Table 3. Characteristics of 28 pediatric patients with spleen injury (numbers or explanations in parentheses show the individual patient values).

		Grade 1 (n:3)	Grade 2 (n:12)	Grade 3 (n:10)	Grade 4 (n:2)	Grade 5 (n:1)	All groups (n:28)
Mean age		7.6	8.9	12.3	12	10	(10.16)
Sex (F/M)		2/1	4/8	1/9	0/2	0/1	7/21
Treatment (Splenectomy /NOM)		0/3	0/12	0/10	0/2	1/1	1/27
ICU (+/-)		0	0	1	1	0	2
Hospitalization time (day)		1.7	5.2	7.0	11.0	4.0	5.8
Cause of trauma	Passenger injury	1	4	1	-	-	6
	Pedestrian injury	-	2	3	-	-	5
	Fall from high	1	2	3	1	1	8
	Fall	-	2	3	-	-	5
	Assault	1	2	-	1	-	4
Other injuries (16 patients)	Liver injury	-	3	-	-	-	3
	Lung contusion	-	2	3	-	-	5
	Pneumothorax	-	2	-	1	-	3
	Pleural effusion	-	-	1	1	-	2
	Cranial	1	2	1	-	-	4
	Bone fracture	-	1	3	-	1	5
Initial Hb level (mg/dL)		11.93	11.88	12.87	11.0	10.9	12.14
Mean fall in Hb (mg/dL)		0.73	0.95	1.22	2.15	2.1	1.15
Thrombocytopenia (<160x 10^3 μ)		0	0	3 **(150-102-106)**	1 **(154)**	0	4
Thrombocytosis (>450 x 10^3 μ)		0	1 **(476)**	0	2 **(1987-702)**	1 **(1058)**	4
Howell-Jolly bodies		0	0	0	2	Unknown	2
INR (0.8-1.2)	Unknown	3	7	5	1	1	17
	Normal	0	3	2	0	0	5
	High	0	2	3	1	0	6
FFP Transfusion		0	1 **(INR unknown)**	2 **(INR high)**	1 **(INR high)**	1 **(INR unknown)**	5
ES Transfusion		0	1	0	1	1	3

F: female, M:male, NOM: non-operative management, ICU: intensive care unit, Hb:hemoglobin, INR: international normalized ratio, ES: erythrocyte suspension, FFP: fresh frozen plasma

Twelve patients had isolated spleen injuries and 16 patients had additional injuries such as extremity fractures (4), hemopneumothorax (2), pneumothorax (1), pleural effusion (1), lung contusion (3), head trauma (1 minor head trauma, 1 cerebral edema, 1 linear temporooccipital fracture, 1 subarachnoid hemorrhage), and liver lacerations (G1, G2 and G3, 1 each). Three of them had tube thoracostomy. No other early intervention was needed in other patients other than splinting of the extremity fractures.

Grading of the spleen injury was done by using the contrast enhanced computerized tomography (CT) in 25 children and ultrasonography (US) or Doppler US in 3 children. Injury grade was detected as G1 in 3 patients, G2 in 12 patients, G3 in 10 patients, G4 in 2 patients, and G5 in 1 patient.

Decline in hemoglobin levels during the hospitalization was between 0.0-3.4 mg/dL (mean 1.16 g/dL). Five patients received FFP and 3 of these received also ES. ES was administered to G5 patients, one G4 patient, and one G2 patient with liver laceration.

There was a decrease in thrombocyte count in 4 patients. None of the patients needed thrombocyte infusion.

There was a thrombocytosis in 4 patients (one with G2, two with G4 and one with G5 spleen injury). G2 patient additionally had hemopneumothorax and her thrombocyte count was minimally high and returned to normal within 10 days. One G4 patient had isolated spleen injury and the second one had pneumothorax with pleural effusion. The thrombocyte level of the patients continued to increase on the 3rd day of the hospitalization. Howell-Jolly bodies were detected in peripheral blood smears. They both received prophylactic antibiotics and one was vaccinated after the hematological evaluation because of the suspicion of malfunctioning spleen. According to the spleen scintigraphy results, it was shown that the spleen of the first patient maintained its normal function after the 3 months of follow-up. Furthermore, Howell-Jolly bodies disappeared according to the results of peripheral blood staining. Thrombocyte counts also returned to normal at the end of 3 months. Second G4 patient had the follow-up with Doppler US and peripheral blood smear and patient's thrombocyte count returned to normal at the end of 1 month. Furthermore, patient's spleen perfusion returned to normal within 3 months. There were no Howell-Jolly bodies in his control blood smear.

Grade 5 patient needed an immediate splenectomy after the CT findings of major devascularization of the spleen. Splenectomy was performed only for this patient. Additionally, he had also a humerus fracture. Patient's thrombocyte count started to increase on the postoperative 4th day and it reached its highest level on the postoperative 9th day. It was observed that thrombocyte level was still high 3 months later and it returned to its normal level 2 years after splenectomy.

Hospital stay duration was between 1 and 18 days (mean 5.64 days). Re-bleeding was developed in one G3 patient 5 days after the discharge and it was successfully managed with the help of the conservative treatment. Furthermore, pre-discharge ultrasonography was performed especially in patients with hematomas or lacerations near the hilus. There was no mortality observed.

DISCUSSION

Although the study was conducted with a small group of patients and patients had concomitant injuries in addition to spleen injuries, our management protocol was successfully performed. Regarding the spleen preservation, our results are better than the results of other series because none of the grade 3 or grade 4 patients experienced spleen loss (1, 12). Spleen loss was observed in only one patient with a G5 injury and the patient needed an immediate splenectomy.

Fluid requirements of children are different than adults. The excessive fluid load can restart the already stopped bleeding by raising the blood pressure (14). Especially in trauma centers which do not treat pediatric patients, fluids usually are administered to the child without any restriction after inserting an intravenous line. In one study, authors have found that children are resistant to adverse effects of early high volume crystalloid solutions (15). It also has been shown that children have a longer length of hospital stay and their mechanical ventilation need increase in case they receive high amounts of fluid. There is not much evidence about the efficiency of damage control resuscitation in children which includes permissive hypotension and early blood product administration if there is serious blood loss (14). The protocol that is used in our study provided maintenance of the fluid requirements without causing overload or hypotension.

One of the problems of fluid administration is that parameters such as blood pressure and pulse values are not reliable predictors of fluid loss in children. Normal blood pressure or pulse values do not necessarily mean that there is no hypovolemia in a patient. If there is no serious kidney or head trauma, the amount of the fluid that will be administered was adjusted according to the urinary output in our patients. In high grade injuries, urinary catheter was inserted and the output was followed in an hourly basis and fluid adjustments were made at 8 hourly intervals. Head injuries were not serious and they were managed with great care after consulting the fluid requirements of the child with neurosurgeons. We did not encounter any adverse effect related to our fluid protocol. No extreme low hemoglobin levels were observed in our patients because the fluid administration did not lead to hemodilution nor re-bleeding during hospitalization.

Only 17.9% of the patients who had high grade or concomitant injuries received blood or blood products. Fresh frozen plasma was administered to these patients according to 1:1:1 massive transfusion protocol. This is in accordance with the rate that is used in a multicenter study (1). When compared to ATOMAC guidelines (Figure 1) (13), transfusion cutoff of 8 g/dL in the series is higher than the offered value 7 g/dL. This may be because the surgeons want to feel more comfortable.

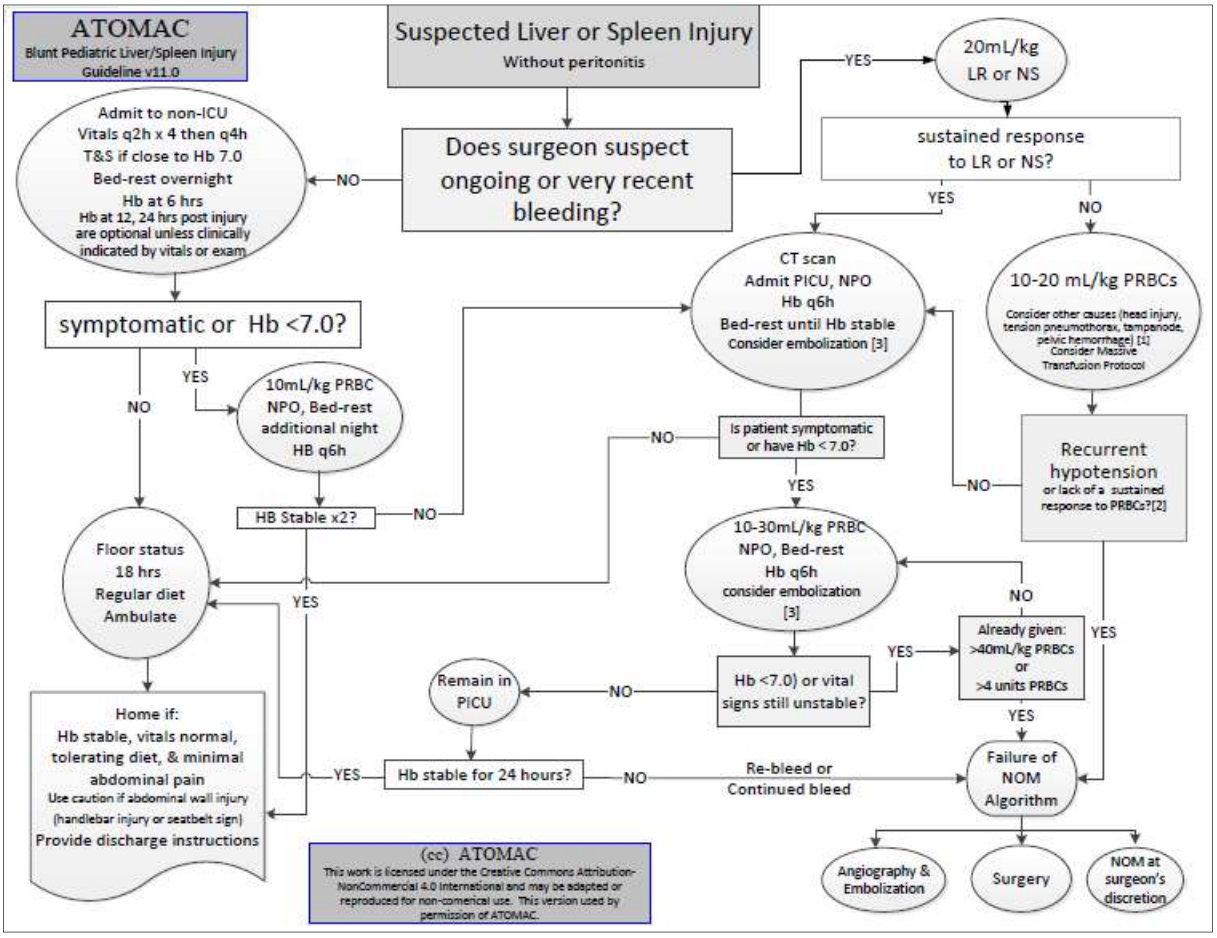

Figure 1. ATOMAC guideline for management of pediatric liver/spleen injury (13)

Thrombocyte counts decreased in the first 24 hours of the injury in almost all patients. Only four patients had thrombocyte levels below normal limits. None of the patients needed the thrombocyte transfusion. Thrombocyte count is important especially in the presence of hematoma or free intra-abdominal blood in solid organ injuries.

Another finding in this study is that spleens of G4 patients were severely damaged and probably they did not show a regular function for a while and lost their capacity as a reservoir for blood cells. This was shown as a result of an increase in thrombocyte counts starting 3-4 days after the injury and reaching 2 million in one of the patients. These patients were considered as if they had splenectomy. Spleen functions were normal in these patients after three months of follow-up. Thrombocytosis may occur in the spleen without a proper function or after a splenectomy (8, 16, 17). Post-splenectomy thrombocytosis after trauma in adults is well described and searched (8). In our study, post-splenectomy thrombocytosis was observed in our splenectomized patient.

There are few reports about thrombocytosis regarding non-operative management of spleen trauma in children and adults (16, 17). Thrombocytosis may be a predictor of the spleen hypofunction (9) and reactive thrombocytosis may also occur as a result of an infection (17). We did not detect any infection in our G4 patients, but we showed the presence of Howell-Jolly bodies which is a normal finding in splenectomized patients. Severely injured spleen seems to lose its function and capacity as a reservoir. These changes were transient in our patients. No thromboembolic complications were developed. We believe that separate management protocols are needed for high grade spleen injury patients. It would be rational to quantify the thrombocyte counts at least for three or four days in severely damaged spleens.

The proposed length of hospital stay depends on the severity of the spleen injury. It is 24 hours for G1 injuries and 96-120 hours for G5 injuries (1, 2). In our study, mean hospital stay duration was 5.64 days and there were concomitant injuries in more than half of the patients. We still believe that this finding is comparable with findings of other studies (1).

One of our patients who was living in a remote area had a late bleeding and thus a control ultrasonography (US) was performed before the discharge of all patients. US is not recommended as a pre-discharge imaging modality by some centers (1, 2), but we considered that patients living in remote areas are under a risk factor for mortality or morbidity due to re-bleeding. Therefore, we preferred to perform US before the discharge, especially if there is a hematoma or a laceration near the hilus.

The protocol that was used in the study was successfully applied. There was only one case with spleen loss. Fluid protocol did not lead to any adverse effect regarding the kidney or brain functions and it did not cause re-bleeding during hospitalization. Urinary output was found helpful in managing the fluid resuscitation. In grade 4 injuries, there was a thrombocytosis and Howell-Jolly bodies indicated the impaired function of spleen even though this was transient. Major restrictions of this study are: 1) the study group was not a standard group because only 12 patients had isolated spleen injuries, 2) this is a small group, 3) it is a retrospective study. A large-scale study is required for the fluid management after the child is selected for NOM and also for the management of high-grade spleen injuries.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Formal consent is not required for this type of study.

Conflict of interest

No conflict of interest was declared by the authors.

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