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ORIGINAL ARTICLE

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Diagnostic imaging in the follow-up of nonoperative management of splenic trauma in children

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Abstract The spleen is the most frequently injured organ in blunt abdominal trauma (BAT). Contrast-enhanced computed tomography (CT) is approximately 95% sensitive and specific for detection of splenic injury. In children, nonoperative treatment is well-established. The basic tenet of such management is an obligatory period of rest to prevent recurrent bleeding and allow splenic healing. Splenic preservation prevents post-splenectomy sepsis. At our level I trauma center, pediatric patients (N = 54) with BAT between 1993 and 1998 were retrospectively studied. Two (3.7%) died of associated injuries; 2 underwent splenectomy before transfer to our hospital. All had been diagnosed with splenic injury by CT. The mean age was 11.3 years. The mechanisms of injury were motor vehicle accidents (66%), bicycle accidents (26%), and falls (8%). All 50 remaining patients were followed by ultrasound (US) after the initial diagnosis by CT. The mean hospital stay was 6 days. One patient developed the rare complication of an arterio venous (AV) fistula within the damaged spleen; 47 (94%) had normal, homogeneous parenchymal echogenicity at healing (including the patient with the AV fistula). The remaining 3 demonstrated a visible echogenic scar. Imaging documentation of healing blunt splenic trauma should ideally minimize cost and relative risk. Our results add further evidence that US is well-suited to the task. No delayed complications with this approach were recorded in this series.

Keywords Blunt abdominal trauma · Splenic trauma · Computed tomography · Ultrasonography · Children

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Introduction

The spleen is the most frequently injured organ after blunt trauma to the abdomen. In the pediatric patient who remains hemodynamically stable after blunt trauma to the spleen (BTS), nonsurgical management has become the standard of care [1, 2]. Documentation of splenic healing with noninvasive imaging is often the benchmark cited. Reports in the literature exist examining the use of computed tomography (CT) for this purpose [3, 4]. Late complications of BTS, while rare, are documented [5], and can include pseudoaneurysm formation, delayed rupture, or pseudocyst formation.

Physicians and surgeons caring for these patients must carefully balance the risk of transfusions, missing associated injuries, and late sequelae against the ever-increasing economic pressure to optimally utilize hospital resources. Ultrasonography (US) has assumed a useful role in this connection [6, 7]. Although CT is approximately 95% sensitive and specific for detection of splenic injuries and late sequelae [3], US is less expensive and does not use radiation or contrast material. The present study endeavored to determine the usefulness of US in assessing the healing of splenic injuries.

Materials and methods

At our level I trauma center, 54 pediatric patients admitted between January 1993 and October 1999 with BTS, and their records were retrospectively studied. Two underwent a splenectomy before transfer to our hospital; 2 died of associated neurologic injuries. The remaining 50 patients were treated nonoperatively. The criteria for this management included hemodynamic stability and the absence of other abdominal injuries requiring a laparotomy.

At the time of injury, all 50 patients underwent CT scans of the abdomen and pelvis at either our institution or the referring institution after an IV bolus of nonionic contrast with 5–7 mm section

collimation. All CT scans were retrospectively reviewed, and the splenic injuries were graded according to Buntain's classification [8].

Follow-up US was performed upon discharge from the hospital 6 weeks later, and then every 6 to 8 weeks (depending upon the findings) to assess the healing of the splenic laceration (Table 1, Figs. 1, 2, 3). While CT is imperative for the initial assessment, sequential US studies in conjunction with clinical findings lead to the premise that healing is complete.

Results

All 50 patients returned for follow-up US. The mean age was 11.3 years (range 6–17 years). All 50 were followed to complete healing; 47 have normal sonograms, while 3 have small echogenic scars. One patient developed a transient arteriovenous fistula, which was followed to resolution by US.

The number of transfusions required was inversely proportional to the patient's age (i.e., the youngest required greater numbers of transfusions). The average number of units of 250 ml packed red blood cells was 3 (Table 2). The average hospital stay was 6 days (range 1–17). The length of stay and total number of pediatric intensive care unit (PICU) days were directly proportional to the grade of splenic injury (Table 3). As expected, associated injuries were more frequent with higher-grade lesions. These included skeletal fractures (62%), pulmonary contusions (54%), and liver lacerations (6% (Table 4)). The injury severity score was also proportional to the grade of splenic laceration (Table 5).

All patients in this study, were admitted to the PICU until hemodynamic stability was achieved and management of their associated injuries was optimized. The criteria for blood transfusions were a hematocrit less than 25% with an associated heart rate of 120/min or greater and a systolic blood pressure below 80 mmHg despite volume replacement with crystalloids.

All patients were placed on quiet activity in the hospital and light activity for 3 months, after which, they returned to unrestricted activity. Serial US examinations were terminated when the endpoint of splenic healing (anatomic integrity without free fluid) was reached. This differed in different patients, and hence the differences in total follow-up times. No delayed complications with this approach to BTS were recorded in this series.

Table 1. Imaging studies and length of follow-up

	No. of cases
CT of abdomen/pelvis (with contrast)	
Initial	50
Follow-up	4
US of abdomen/pelvis	
Before hospital discharge	50
At 6–8-week intervals	50
Length of follow-up (months)	
< 3	10
3–6	36
> 6	4

Fig. 1. Axial contrast-enhanced CT scan of abdomen following blunt splenic trauma: grade IV splenic laceration [*L* liver, *S* lacerated spleen, *B* blood (≥45 Hounsfield units), *A* aorta]

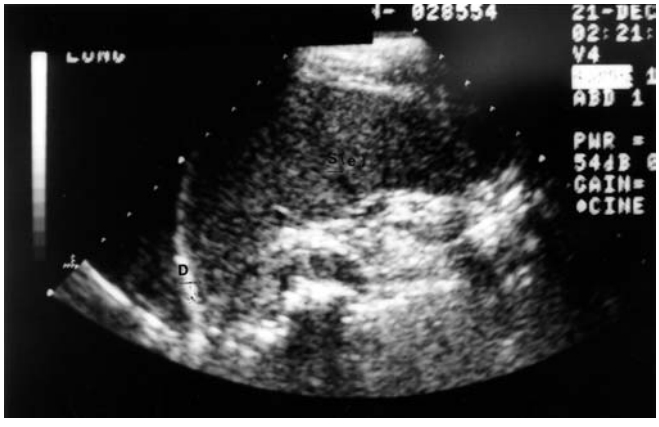

Fig. 2. US scan after grade IV splenic laceration, 12 weeks after hospital discharge; increased echogenicity (scarring) seen in parenchyma (*S* spleen, *E* increased echogenicity with anatomic integrity, *D* diaphragm)

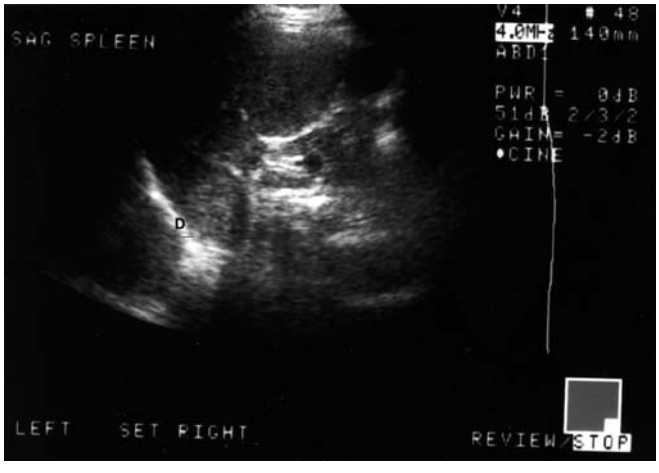

Fig. 3. US scan after grade II splenic laceration, 12 weeks after hospital discharge; normal echogenicity of spleen (*S* spleen, *D* diaphragm)

Table 2. Initial hematocrit and numbers of transfusions required according to grade of splenic injury (Buntain's classification)

	Grade of injury			
	I	II	III	IV
Initial hematocrit (%) (mean)	36	33	31	27
Transfusion units needed[a]				
Range	0–2	2–4	3–4	3–4
Mean	1.6	3.1	3.3	3.8

[a]1 unit = 250 ml packed RBCs

Table 3. ICU and total hospital stay according to grade of splenic injury (Buntain's classification)

	Grade			
	I	II	III	IV
ICU stay (days)				
Range	1–2	1–3	3–6	3–7
Mean	1.1	1.6	4.9	4.4
Total hospital stay (days)				
Range	2–5	3–6	6–10	6–17
Mean	3.8	4.7	7.3	8.2

Table 4. Mechanism of injury and associated injuries

	No. of Cases	%
Mechanism of Injury		
Motor vehicle accident	33	66
Bicycle accident	13	26
Falls	4	8
Associated injuries		
Skeletal fractures	31	62
Pulmonary contusions	27	54
Liver lacerations	3	6

Table 5. Age distribution of patients with splenic injury

	Buntain grade			
	I	II	III	IV
Number of cases	10	26	9	5
Age (years)				
1–9	4	11	1	1
10–17	6	15	8	4
Injury severity score (range)	3–12	12–22	22–36	36–50

Discussion

The evolving understanding of the spleen's role in immunologic surveillance and postsplenectomy sepsis has dramatically decreased splenectomy as a routine procedure after pediatric splenic injury [5]. Nonoperative management of pediatric BTS has now become the standard of care. A well-accepted principle is an obligatory period of restricted physical activity after hospital discharge to prevent recurrent bleeding.

Serial outpatient abdominal US provides objective data to suggest splenic healing based upon the return of normal, homogeneous echogenicity of the spleen. If US resolution is deemed equivalent to true anatomic integrity of the spleen, it can be logically concluded that serial US examinations may be used to follow the natural history of pediatric splenic injuries managed nonoperatively [9, 10].

The present study demonstrates that follow-up can be reliably and accurately obtained using US with its inherent benefits of lower cost, no contrast exposure, and lack of ionizing radiation. Hemodynamically stable patients with the most severe splenic trauma (grade IV) were safely treated with an average 8-day hospital stay followed by 3 months of light activity before return to full, unrestricted activity. All patients had US demonstration of resolution of the splenic injury before resuming full activities.

Our results support the value of US in assessing the healing of splenic lacerations and recommending the resumption of regular physical activity.

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