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Original Article

# The Spleen After Blunt Injuries in Children: A Salvageable Organ with Conservative Treatment

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**Abstract: Background**: During last decades, management of patients with Blunt Splenic Trauma shifted towards non-Operative Management. As spleen is an important part of our immune system, spleen should be salvaged. **Patients and methods**: This is a single center retrospective study, including (59 patients). monitoring of clinical and laboratory parameters was done in the intensive care unit (ICU). Grading of splenic injury based on CT with IV contrast finding. **Results** 59 patients were included with a mean age of 5±2.5 SD years. 35 males and 24females. All patients managed non-operatively. Falling from height was most common cause of trauma (52.5%). The most common associated injury was lower rib fracture with hemothorax in (18.6%). AAST grade I was noted in (27.1%), grade II in (50.8%), (11.9%) Patients received blood transfusion during the study period by 1 mg\kg of backed RBCs once for each patient. The mean length of hospital stay was 4.7 ± 2.5 SD days. No major complications were observed during the study period and no mortality among cases.

Conclusion This single institution's experience over one-year reports no deaths and no splenectomies. Splenectomy has become very unusual in hemodynamically stable children with a splenic injury. The use of clinical practice guidelines has assisted with the management of this condition, especially in making the care more efficient, so we think that spleen is a salvageable organ in cases of pediatric splenic trauma and we recommend a larger study including more patients for better results.

**Keywords:** blunt abdominal trauma, hemoperitoneum, road traffic

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## Introduction:

One of the most commonly injured organs in abdominal trauma is the spleen, which can present with injuries in as many as 16% to 23.8% of polytraumatized patients and has a 9.3% fatality rate, mostly as a result of related injuries and postponed treatment.[1]

Removing a damaged spleen was standard surgical procedure 25 years ago. Actually, it was deemed to be absurd to try to save a spleen that had been torn, even if it had only been slightly injured. Given the global acceptance of cautious management, one could naturally wonder: [1] How did splenectomy for trauma continue to be a sacred surgical practice for centuries? [2] Why didn't surgeons challenge its scientific foundation? [3] How did the new splenic salvage policy develop?[2]

The spleen, a crucial component of our immune system, removes red blood cells, germs, and other cellular and non-cellular substances from the blood and plasma, including macrophages. Because splenectomy can result in septicemia, opportunistic post-splenectomy infections, and malaria, the spleen should be preserved wherever possible.[3]

As the spleen is a common organ injured by blunt abdominal trauma, splenectomy is usually carried out to prevent hemorrhagic shock. Due to the immune functions of the spleen, infections like post-splenectomy sepsis, malaria, and pneumonia can occur after a splenectomy. [4] In recent decades, conservative treatment of splenic damage and other abdominal organs has grown in popularity. In cases of blunt splenic injuries, these spleen-saving techniques have been demonstrated to be both safe and successful in preserving the spleen's immune function.[5]

Conservative treatment is now the norm for patients with blunt spleen injuries who are hemodynamically stable. [4] According to the research, conservative treatments have a success rate of over 90% and a failure rate of only 8%.[6]

Non-Operative Management (NOM) has become increasingly prevalent in the treatment of stable hemodynamic patients with Blunt Splenic Trauma (BST) over the past few decades.[7]

There are clear advantages to non-operative care, including avoiding surgery, protecting the spleen and its immune system to prevent OPSI, lowering hospital expenses, the incidence of intra-abdominal problems, and the need for blood component transfusions. In high-volume trauma facilities, conservative care is said to have a nearly 90% success rate.[8]

Due to this knowledge of increased risk of susceptibility to infection after splenectomy, with its most deadly manifestation, overwhelming post-splenectomy infection, occurring in about 0.5% of all splenectomies in trauma patients and in over 20% of elective splenectomies for hematological disorders, led to a paradigm shift in the management of blunt splenic injury. NOM of splenic injuries has gradually become the standard of therapy in patients who are hemodynamically stable. [9]

Splenic lesions are most often classified according to the American Association for the Surgery of Trauma (AAST) Organ Injury Scale. Grade I and II lesions have a risk of rebleeding below 20% .[10]

The risk of grade III, IV, and V lesions is more than 20%, 50% when contrast extravasation is present, and 70% when there is widespread hemoperitoneum (blood in the pelvis, paracolic gutters, and perisplenic recess). Grade I to V injury rates were 8–13%, 22–37%, 25–39%, 16–25%, and 6-9%, respectively, in two recent retrospective studies. [11]

Even though the literature has a wealth of research on the indications for NOM of splenic injuries, there aren't many papers that describe the progression of the chosen patients or commonly accepted techniques for conducting NOM. One There are still some contentious issues surrounding these patients' follow-up. These include how often laboratory tests and clinical reevaluations are performed, how long a patient is monitored, when to start venous thromboembolism (VTE) prophylaxis, when to start bed rest and hospitalization, when to start immunization after spleen embolization and after extensive splenic injury submitted to NOM, when to use control imaging, and when to follow up with patients after being discharged from the hospital.

### Aim of the work:

To evaluate the effectiveness of conservative management for splenic injuries in blunt abdominal

trauma in pediatric age group in single center at Sohag university hospital.

## Patients and methods

This is a single center retrospective study, including all patients admitted to pediatric surgery department at Sohag university hospital from January 2023 to January 2024.

59 patients enrolled in the study all of them came to the emergency department with blunt abdominal trauma and CT abdomen and pelvis with contrast done for all of them.

This study was performed after approval granted by the Institutional Medical and Ethics committee of Sohag Faculty of Medicine.

After the initial resuscitation, as well as fluid resuscitation according to early management recommendations for severe trauma, primary and secondary trauma surveys were done for all patients with assessment by all trauma team to exclude other associated injuries. All patients were treated using intravenous fluids, nasogastric tube decompression, and nothing by mouth. Intravenous antibiotics were administered to patients who had contaminated external injuries.

Then, hemodynamically stable patients and those whose hemodynamic status improved after initial resuscitation underwent CT scans of the abdomen and pelvis. Following the administration of IV contrast, an abdominal CT scan was taken. On the basis of the CT scan appearance, splenic injuries were graded based on the organ injury scale. Injuries were classified according to the American Association for the Surgery of Trauma Organ Injury Scale (AAST-OIS) grading system. **Table 1**

A routine hemogram, serum biochemistry, and blood typing analysis were performed. Close monitoring of clinical and laboratory parameters was done in the intensive care unit (ICU). Pulse and blood pressure (BP), were monitored hourly. Hemoglobin and packed cell volume (PCV) were monitored every six hours. Clinical examinations were repeated at regular intervals to look for peritonitis symptoms developing in the abdomen.

Patients who experienced a drop in hemoglobin below 7 g/dL received blood transfusions. All patients were observed in the ICU for at least 48 hours before being transferred to the general pediatric surgery department. Each patient underwent a radiological review with ultrasound scanning on admission and follow up daily after admission as well as right before hospital discharge. Those patients who failed conservative management due to hemodynamic instability, a sustained decline in hemoglobin, or peritonitis underwent laparotomies.

**Follow up:** all patients were followed up after being discharged weekly for one month and monthly for six months clinically and radiologically by abdominal US examination for fear of complications such as pseudoaneurysm of spleen, splenic cyst or splenic abscess.

**Data collection:**

All data were recorded, tabulated and statistically evaluated.

Data analysis was performed using Statistical Package for Social Sciences (SPSS), version 20, Chicago, US

Results described the percentage and values of the study. Data were summarized as the mean +\- standard deviation for the numerical variables and numbers (percentages) for non-parametric values.

**Table 1:** AAST of Splenic trauma

| Grade | Injury description | |
|---|---|---|
| **Grade I** | Hematoma | Subcapsular hematoma <10% of surface area |
| | Laceration | Capsular tear < 1 cm of parenchymal depth |
| **Grade II** | Hematoma | Subcapsular 10- 50% of surface area, or intraparenchymal <5 cm diameter |
| | Laceration | Capsular tear 1-3 cm parenchymal depth but not involve trabecular vessels |
| **Grade III** | Hematoma | Subcapsular > 50% of surface area, expanding ruptured subcapsular or parenchymal hematoma > 5 cm or expanding |
| | Laceration | >3 cm parenchymal depth or involving trabecular vessels |
| **Grade IV** | Laceration involving segmental or hilar vessels producing significant devascularization (<25% of spleen) | |
| **Grade V** | Completely shattered spleen<br>Or hilar vascular injury with devascularised spleen | |

## Results:

During the study period from January 2023 to January 2024 a total of 59 patients were included in the study with a mean age of 5±2.5 SD years. there were 35 (59.3%) males and 24 (40.7%) females **Table 2** 57 patients (96.6%) managed conservatively and only 2 patients (3.4%) failed conservative management and were sent to the operative theatre for splenectomy. **Figure 1, 2&3**

Falling from height was the most common cause of trauma at 31(52.5%) cases, followed by road traffic accident with 27 (45.8%) cases and 1 case has had heavy object falling on the abdomen (1.7%), **Figure 4** The most common associated injury was lower rib fracture with hemothorax in 11 (18.6%) cases, followed by hepatic injury in 9 (15.3%), femur fracture in 5 (8.5%), and renal injury in 1 (1.7%) case. **Table 3**

Based on the CT scan **Table 4:** AAST grade I was noted in 16 (27.1%) cases, **Figure 5&6** grade II in 30 (50.8%) cases **Figure 7&9,** grade III in 9 (15.3%) cases, **Figure 9&10.** and grade IV in 4 (6.8%) cases **Figure 11,12&13**. based on the initial us finding **Table 5**: Minimal hemoperitoneum was observed in 18 (30.5%) cases, mild hemoperitoneum was noted in 33 (55.9%) cases and moderate hemoperitoneum was noted in 8 (13.6 %) cases. There was neither a massive hemoperitoneum nor no hemoperitoneum. **Figure 12**

7 (11.9%) Patients received blood transfusion during the study period by 10 mg\kg of backed RBCs once for each patient. Initial hemoglobin level range was 9.3±1.4 SD gm\dl in our study.

The mean length of hospital stay was 4.7 ± 2.5 SD days

No major complications were observed during the study period and no mortality among cases.

The 2 cases in whom conservative management failed were: The first was a male child aged 6 years and 5 months with a history of road traffic accident, AAST grade VI with moderate hemoperitoneum and associated with femur fracture **Figure 2**. The second patient was a female child aged 5 years with history of road traffic accident, ASST grade VI with moderate hemoperitoneum and also associated with femur fracture this patient came hemodynamically unstable and we couldn't arrange for CT abdomen and pelvis for her and sent to the operative theatre after initial resuscitation . **Figure 3**

**Table 2:** Comparison between successful and failed conservative therapy as regards age and gender

| Variables | Successful conservative therapy (n=57) | Failed conservative therapy (n=2) | Test | P- value |
|---|---|---|---|---|
| **Age** | | | 1.32 | 0.87 |
| Mean ± SD | 4.4±2.3 | 5.4±2.6 | | |
| **Gender** | | | 1.21 | 0.61 |
| Male | 34(59.6%) | 1(50%) | | |
| Female | 23(40.4%) | 1(50%) | | |

Shows that there was insignificant difference between successful and failed conservative therapy as regards age and gender (p >0.05)

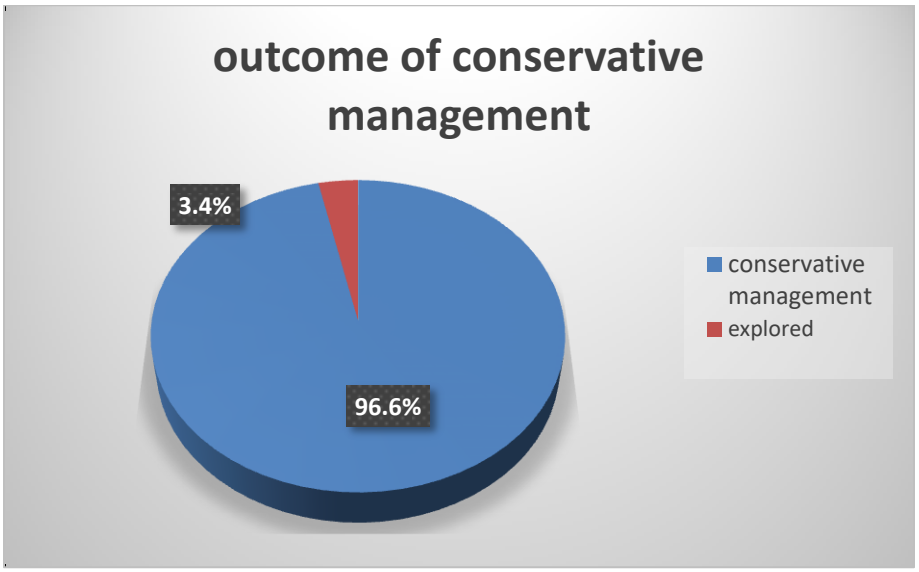


**Figure 1.**showing the outcome of conservative management in our patients

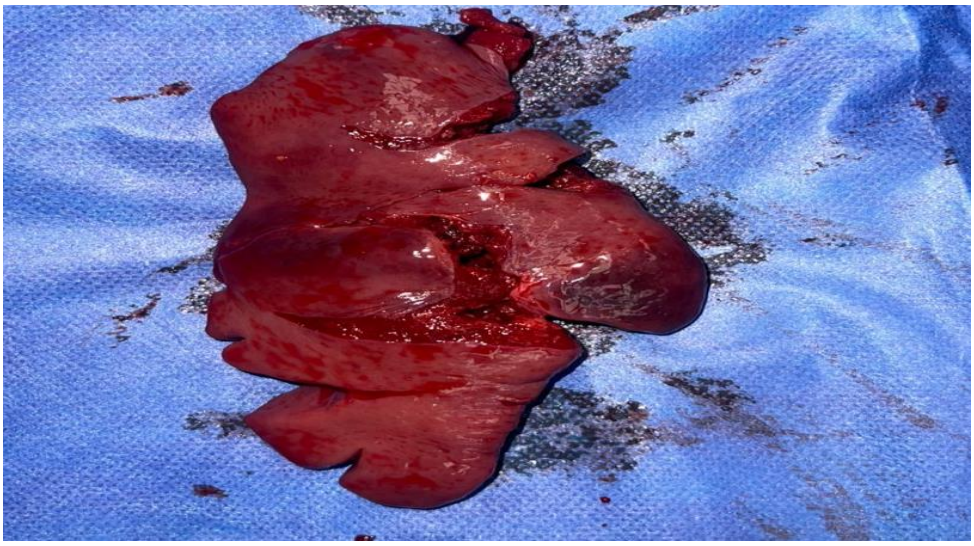

**Figure 2.** operative photo for grade VI splenic injury

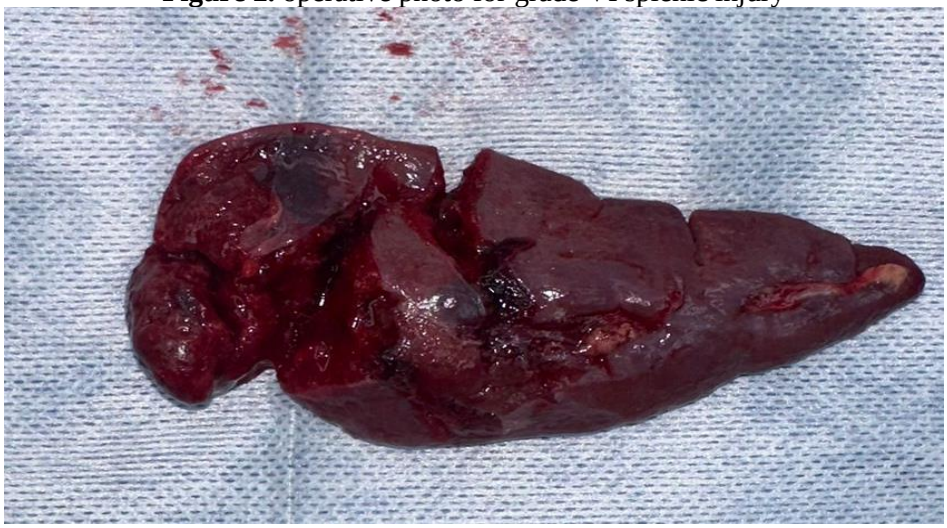

**Figure 3.** operative photo for grade VI splenic injury

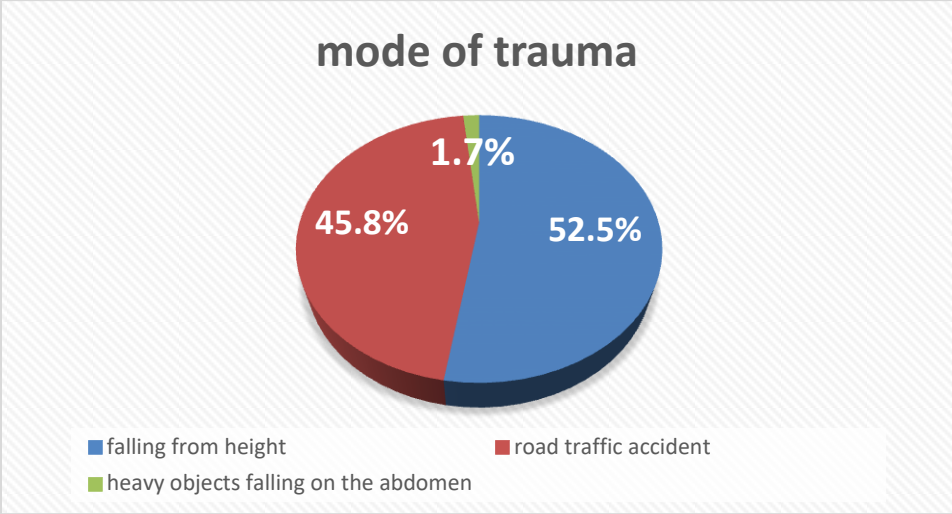


**Figure 4 .** percentage of mode of trauma

**Table 3:** Comparison between successful and failed conservative therapy as regards associated injuries

| Associated injury | Successful conservative therapy (n=57) | Failed conservative therapy (n=2) | Test | P- value |
|---|---|---|---|---|
| **Lower rib fracture with hemothorax** | 11 (19.3%) | 0(0%) | 4.25 | 0.001* |
| **Hepatic injury** | 9(15.8%) | 0(0%) | | |
| **Femur fracture** | 3(5.3%) | 2(100%) | | |
| **Renal injury** | 1(1.8%) | 0(0%) | | |

Shows that femur fracture was significantly higher among failed therapy compared to Successful conservative therapy as regards ASST grade ($p<0.05$).

**Table 4:** Comparison between successful and failed conservative therapy as ASST grade

| ASST grade | Successful conservative therapy (n=57) | Failed conservative therapy (n=2) | Test | P- value |
|---|---|---|---|---|
| I | 16 (28.1%) | 0 (0%) | 6.32 | 0.001* |
| **II** | 30(52.6%) | 0(0%) | | |
| **III** | 9(15.8%) | 0(0%) | | |
| **IV** | 2(3.5%) | 2(100%) | | |

Shows that ASST **IV** grade was significantly higher among failed therapy compared to successful conservative therapy as regards ASST grade ($p<0.05$)

**Figure 5.** axial sections grade I AAST splenic injury

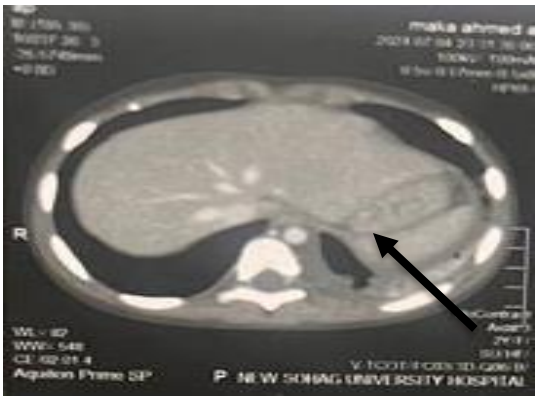

**Figure 6.** coronal section CT

Abdomen and pelvis grade I AAST arrow showing sub capsular hematoma

arrow showing splenic laceration <1 cm

**Figure 7**. grade II AAST splenic injury Arrow showing splenic laceration <3cm

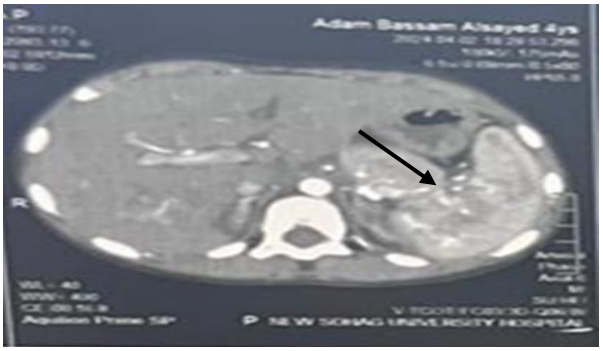

**Figure 8**. grade II AAST splenic injury arrow showing hematoma with lacerat <3cm

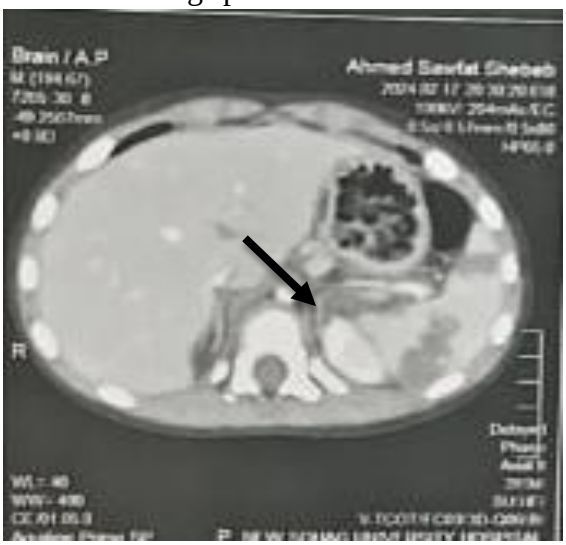


**Figure 9** grade III AAST splenic injury Arrow showing sub capsular hematoma with laceration > 3 cm

**Figure 10** grade III AAST splenic injury Arrow showing sub capsular hematoma with laceration > 3 cm

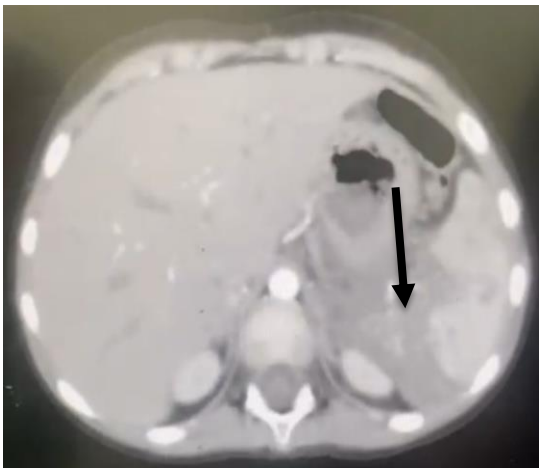

**Figure 11**

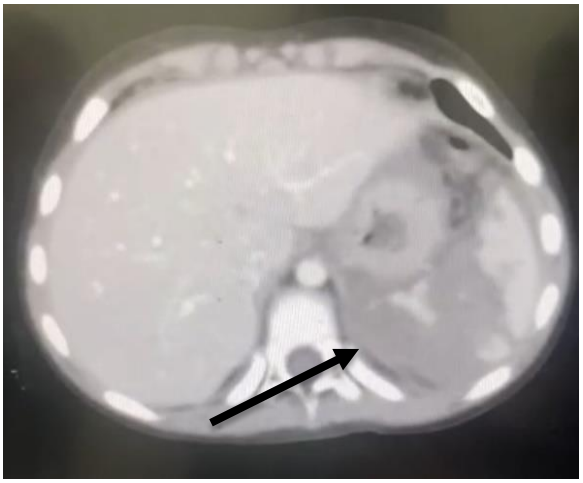

**Figure 12**

Extensive laceration and devascularization about 5x4 cm with intraparenchymal and Peri splenic hematoma no evidence extravasation

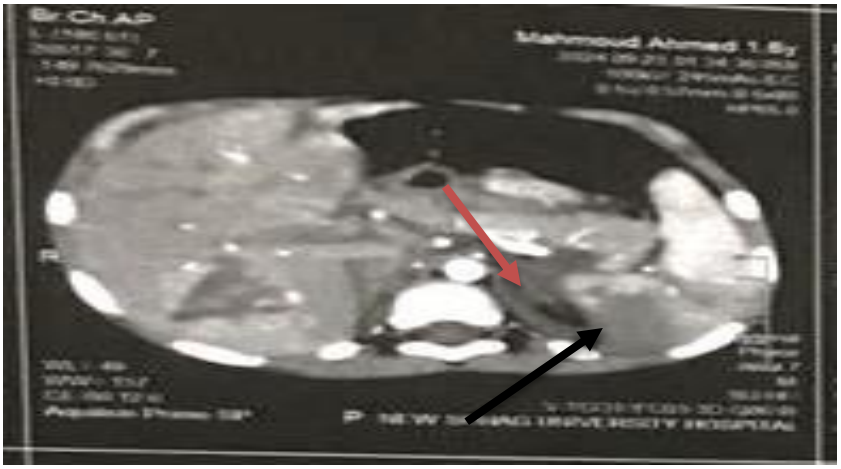

**Figure 13**: grade IV splenic injury with grade II hepatic injury Red arrow>> Linear laceration and hematoma seen at segment VII, **black** arrow laceration filled intraparenchymal hematoma extended at middle and lower zones.

**Table 5:** Comparison between successful and failed conservative therapy as regards US findings

| US finding | Successful conservative therapy (n=57) | Failed conservative therapy (n=2) | Test | P- value |
|---|---|---|---|---|
| **Minimal** | 18(31.6%) | 0(0%) | 5.32 | 0.001* |
| **Mild** | 33(57.9%) | 0(0%) | | |
| **Moderate** | 6(10.5%) | 2(100%) | | |

Shows that moderate hemoperitoneum was significantly higher among failed therapy compared to successful conservative therapy as regard US finding ($p<0.05$).

**Table 6:** Factors associated with failed conservative surgery

| Variables | Univariable models | | Multivariable models | |
|---|---|---|---|---|
| | OR (95%CI) | P-value | OR (95%CI) | P-value |
| **Age (years)** | 1.02 (0.94-1.56) | 0.23 | | |
| **Gender** | 1.01 (0.71-1.22) | 0.45 | | |
| **Moderate hemoperitoneum** | **3.17 (1.57-4.21)** | **0.03*** | **2.47(1.89-3.41)** | **0.04** |
| **ASST grade** | **2.07 (1.15-3.72)** | **0.02*** | 1.52 91.10-2.21) | 0.14 |
| **Hemoglobin level** | 1.52 (0.91-1.66) | 0.25 | | |
| **Hospital stay** | 0.92(0.67-1.19) | 0.31 | | |
| **Femur fracture** | **2.42 (1.52-3.14)** | **<0.01*** | **1.89(1.14-2.11)** | **<0.01*** |

First, we used the univariable logistics regression to analyze important clinical factors which might be associated with failed conservative surgery (**Table 6).** We found that those who had moderate hemoperitoneum, femur fracture with high ASST grade were all associated with failed conservative management. Then, we used multivariable logistics regression to adjust confounding factors. We found that those who had moderate hemoperitoneum, femur fracture with high ASST grade were still associated with failed conservative management.

## Discussion

The spleen is the most common abdominal organ injured in blunt trauma. Because the acceptance of the spleen's important immune functions and the recognition that many pediatric splenectomies were unnecessary, selective nonoperative management of pediatric splenic injuries has become the standard of care. Through selective nonoperative management, 80% to 98% of children injured spleens may be successfully treated without splenectomy.(12)

This information demonstrates the development of a non-operative approach to treating blunt splenic injuries at Sohag University Hospitals over the course of a year, from January 2023 to January 2024.

Examining the article by Adams, S.E. et al., which covered 955 children over a longer time period from 2000 to 2011, we found that 33 of the 59 children treated during that time had an isolated splenic damage.( 12)

Regretfully, not all of our cases are resolved non-operatively; two patients (3.4%) were sent for splenectomy after failing conservative therapy, whereas in Telles et al. 4412 kids in all were admitted to the hospital due to splenic injuries. A splenectomy was performed on about half of these kids [2287 instances, 51.8%]. (13) However, the study by Bairdain et al., which included 20,821 children with splenic injury, was similar to ours. All of them passed conservatively without suffering any fatalities.**(14)**

In contrast to Eldredge et al.'s study, which covered a larger age group with a mean age of 11.26 ± 4.41 years, our study's mean age was 5±2.5 SD years.15. Our study included 59.3% males and 40.7% females in agreement with the study done by Eldredge et al with slight increase in the percentage of males which was 68.9% for males and 31.1% for females.(15)

Falling from a height was the most frequent cause o f splenic injury in the Bairdain et al. study, accounti ng for 43% of cases, which is consistent with our fi ndings (52.5%). **(14)**

In comparison to the study done by Eldredge et al. the total length of hospital stay was 6.4± 10.4 days( **15)**. Our results for the same point were 4.7 ± 2.5 SD days but in agreement with Bairdain et al. study whose results show the mean length of hospital stay 4.8± 2.5 SD days.**(14)**

In our study the main grade of injury by AAST scoring was grade II with 50.8% and the least number of patients was in grade IV with 6.8%. after reviewing the study of Eldredge et al in which the main grade was grade III with 43.1% and the least grades were I and II with 16.6%.(15)

Yuen, S. et al. conducted the study on blood transfusions. In our analysis, seven patients (11.9%) received blood products, all on the first day of hospitalization, whereas four instances (0.9%) with near-isolated grade III splenic injury received blood products within the first four hours of presentation .( 16)

According to this study, conservative surgery failure was linked to moderate hemoperitoneum, femur fractures, and high AAST grades. After that, we accounted for confounding variables using multivariable logistic regression. We discovered that conservative surgery failure was still linked to patients with moderate hemoperitoneum, femur fractures, and high AAST grades.

A Brazilian study by Carvalho et al. (17) concluded that ISS and splenic injury grade have a direct and substantial link with nonoperative therapy failure rate. Associated injuries result in more blood transfusions, longer hospital stays, and a higher rate of NOM failure. This is consistent with the findings of Koca et al. (18) and Crankson,( 19 )Teuben et al. (20 )demonstrated that the presence of a femur fracture enhances the likelihood of conservative treatment failure. Furthermore, they discovered that connected injuries are linked to longer stays in intensive care and hospitalization, greater comorbidities, and increased failure of nonoperative therapy. Children with moderate hemoperitoneum, a femur fracture, and high AAST grade splenic injuries are more likely to require surgical intervention, which can be explained by the severe trauma they have experienced, which has resulted in multiple severe injuries such as a fractured femur, which explains the likelihood of failed conservative therapy. Clinicians must closely follow these patients and consider early intervention if conservative therapy fails to maintain stability or their clinical state deteriorates.(21)

Thankfully all our patients were sent home without major complications or mortalities and put on scheduled follow up in our outpatient clinic.

## Conclusion

This single institution's experience over one-year reports no deaths and no major complications among patients. Splenectomy has become very unusual in hemodynamically stable children with a splenic injury**.** Our study demonstrates the safety of conservative management in hemodynamically stable patients. So, we think that spleen is a salvageable organ in cases of pediatric splenic trauma, and we recommend a larger study including more patients for better results.

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