

# How are left-sided rib fractures associated with splenectomy in cases of splenic injury? A multicentre cohort study from urban India.

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## Research Article

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# Abstract

## Background

Any fracture to the rib cage, particularly the left sided ribs, implies a high impact trauma and higher predisposition to splenic injury. Our hypothesis is that injuries causing fractures to the left sided ribs may indicate a high-grade splenic injury which may require splenectomy. This would help the surgeon working in rural and limited resource settings, to plan splenectomy in hemodynamically stable patients with an undetermined grade of splenic injury. With this hypothesis in mind, we aimed to determine how fractures to the left sided ribs, in cases of splenic injury, are associated with splenectomy.

## Methods

We performed a subgroup analysis of patients with splenic injury from a prospective trauma registry study named 'Towards Improved Trauma Care Outcomes' in India. Categorical variables were analyzed using the chi square test and a binary logistic regression was developed to assess the significance of continuous variables.

## Results

During the study period, a total of 16047 patients were included. Of these, 267 patients suffered from splenic injury and 70 patients required splenectomy. Fractures of the left sided ribs was not associated with splenectomy. Injury severity score (ISS), a lower systolic blood pressure and oxygen saturation at arrival, requirement of blood transfusions within 24 hours of admission and a higher grade of splenic injury (grade 4 and grade 5) were associated with splenectomy.

## Conclusion

In contradiction to our initial hypothesis, we found that left sided rib fractures were not significantly associated with splenectomy. Grade of splenic injury was an important determinant of splenectomy.

## Background

Abdominal trauma constitutes around 10% of all trauma cases and may have a mortality rate of up to 42% (1). Situated in the left upper quadrant of the abdomen, the spleen is protected by the rib cage. Despite this bony protection, it is the most affected solid organ in blunt abdominal trauma - it is involved in 32–42% of all abdominal injuries (2–4).

In the mid 1970's there was a paradigm shift in the management of splenic trauma in favor of non-operative management (NOM), when the spleen's immunological importance and the lifelong risk of

overwhelming post splenectomy sepsis was recognized (5). However, a trial of NOM requires intensive care facilities and timely availability of operative or minimally invasive interventional modalities. In low- and middle-income countries (LMIC), and in rural hospitals such facilities are not readily available, and so splenectomy is still recommended for moderate to severe splenic injuries in these settings (2).

Since appropriate patient selection is crucial for successful management of splenic injuries, research has determined factors that are associated with splenectomy (6–19). Among these factors, the patient's hemodynamic stability, severity of splenic injury and requirement of blood transfusions are clinically most relevant (2).

In the rural LMIC setting, availability of resources like blood banks, intensive care units (ICU), contrast enhanced computed tomography (CECT) scans are infrequent. So, the factor most used for determining the need for urgent splenectomy is the patient's hemodynamic status. The severity of splenic injury is an important determinant in guiding management whenever available. A few authors have used bony injuries as an adjunct to guide decision-making in splenic injury (20,21). While Boris et al found no association between rib fractures and severity of splenic injury, Swaid et al found a clear correlation between severity of pelvic fractures and severity of concomitant splenic injuries (20,21). Teuben et al observed that patients with a femur fracture were more likely to require splenectomy (22).

Any fracture to the rib cage, particularly the left sided ribs, implies a high impact trauma and higher predisposition to splenic injury. Our hypothesis is that injuries causing fractures to the left sided ribs may indicate a high-grade splenic injury which may require splenectomy. The association of fractures to the left sided ribs with splenectomy has not been studied previously. This would help the surgeon working in rural and limited resource settings, to plan splenectomy in hemodynamically stable patients with an undetermined grade of splenic injury. With this hypothesis in mind, we aimed to determine how fractures to the left sided ribs, in cases of splenic injury, are associated with splenectomy.

## **Methodology**

### **Study Design**

We performed a subgroup analysis of patients with splenic injury from a prospective trauma registry study named 'Towards Improved Trauma Care Outcomes' (TITCO, [www.titco.org](http://www.titco.org)) in India (23). All trauma patients admitted to four public tertiary care institutes in three metropolitan cities between October 2013 and December 2015 were included in the study. *Figure SEQ Figure \\* ARABIC 1*

### ***Participants and Data Collection***

Data was collected by one dedicated data collector at each designated center. Patients were followed up until discharge, death or to a maximum of 30 days. The dataset included patient demographics, injuries, vital parameters on admission, laboratory parameters like hemoglobin, and hematocrit, imaging studies,

blood transfusions, surgery done, outcome of the patient and length of hospital and intensive care unit (ICU) stay. Data was filtered for splenic injury using the ICD-10-CM (International Classification of Diseases, Tenth Revision, Clinical Modification) code - S36.0 (24). Patients without details regarding the operative procedure were excluded from the statistical analysis (Fig. 1). Splenic injuries were graded as per the American Association for the Surgery of Trauma 2018 guidelines based on the imaging records and operative findings (7). Rib fractures were diagnosed using either a chest x-ray or CT scan of the chest.

## Statistical Analysis

Categorical variables were analyzed using the chi square test and a binary logistic regression was developed to assess the significance of continuous variables. Statistical significance was set as  $p$  value  $< 0.05$ . Data was analyzed using SPSS 26.0 (Statistical Package for Social Sciences; IBM, Chicago, IL, USA).

## Results

During the study period, data of a total of 16047 patients were included. Out of these, 1134 (7 %) patients suffered from an abdominal injury. There were 267 (23.5 %) patients with splenic injury in this cohort. Out of these 267 patients, there were 20 cases in which exploratory laparotomy was performed, but data regarding splenectomy was not available. So, they were excluded from the analysis. Of the remaining 247 patients, 70 (28%) required splenectomy. The mean age of the population was 27.7 years with males constituting a vast majority (86%). The commonest mechanism for splenic trauma was road traffic injuries (61%). 239 (96.7%) patients suffered from blunt abdominal trauma. The patient demographics, epidemiological data and vital parameters on admission are given in table 1.

<b>Table 1: Distribution of demographic, physiological and Process variables of the cohort</b>		
<b>Variables</b>	<b>n=247</b>	<b>Missing Data</b>
Age	27.7 (±14)	-
Sex		-
Male	213 (86.2%)	
Female	34 (13.9%)	
Type of Injury		-
Blunt	239 (96.7%)	
Penetrating	8 (3.3%)	
Mechanism of Injury		-
Road Traffic Accident	151 (61.1%)	
Fall	61 (24.7%)	
Railway Accident	14 (5.6%)	
Assault	16 (6.5%)	
Other	5 (2.1%)	
Transfer from Other Hospital	133 (53.8%)	1 (0.4%)
Mode of Transport		2 (0.8%)
Ambulance	126 (51.0%)	
Police	40 (16.2%)	
Private Car	49 (19.8%)	
Taxi	30 (12.2%)	
Vitals on Arrival		-
SBP (mmHg)	110 (98-124)	7 (2.8%)
HR (Beats Per Minute)	96 (81.5-110)	4 (1.6%)
RR (Per Minute)	18 (16-20)	19 (7.7%)
Spo2 (%)	100 (99-100)	22 (8.9%)
GCS		15 (6.0%)
Severe (<9)	32 (12.9%)	
Moderate (9-12)	8 (3.2%)	
Mild (13-15)	192 (77.7%)	

Injury Severity Score (ISS)	17 (9-25)	52 (21.0%)
Time from Injury to Admission, minutes	225 (70-705)	9 (3.2%)
Continuous values are listed as median (interquartile range) and categorical variables as count (percentage). Age is listed as mean ( $\pm$ standard deviation)		
SBP Indicates Systolic Blood Pressure, HR, Heart Rate, RR, Respiratory Rate, GCS, Glasgow Coma Scale, SPO2, Oxygen Saturation.		

Injury to the thorax was noted in 113 (45.7%) cases. Out of these, rib fractures were noted in 81 cases. Left sided ribs were fractured in 51 patients. Liver (16.1%) was the most common abdominal organ concomitantly injured followed by the kidneys (11.7%) (Figure 2).

Out of the 247 patients, 235 (95 %) underwent focused assessment with sonography in trauma (FAST) examination, a positive result was seen in 44.5% of the patients. X-rays were performed for 237 (96%) patients. A CECT scan was ordered for 217 (87.8 %) cases.

In this cohort (n=247), 5 patients underwent an emergency surgery within 1 hour of arrival and 89 more patients required operative management within 24 hours of admission. The indications of surgery were diverse, and splenectomy was performed in 70 (26%) cases. 93 (37.6%) patients required PCV transfusions within 24 hours of admission. Mortality was noted in 3 (9%) of grade 1 and 6 (10.5%) of grade 2 injuries. In contrast, mortality was noted in 9 (28%) grade 5 splenic injuries. There were overall 35 (14.1%) deaths in the study cohort (Table 2).

**Table 2 Distribution of Investigations, Surgery and Outcomes of Splenic Trauma Patients**

<b>Investigation and Surgery</b>	<b>n=247</b>	<b>Missing Data</b>
Hemoglobin	10 (9.75-12.25)	18 (7.2%)
Hematocrit	29.4 (0-37.1)	26 (10.5%)
X-Ray	237 (96%)	-
FAST	235 (95%)	-
Positive	110 (44.5%)	
CT scan	217 (87.8%)	-
Grade of Injury		22 (8.9%)
Grade 1	32 (12.9%)	
Grade 2	57 (23.1%)	
Grade 3	58 (23.5%)	
Grade 4	46 (18.7%)	
Grade 5	32 (12.9%)	
Surgery		-
within 1 hour	5 (2.0%)	
from 1 to 24 hours	89 (36.0%)	
Type of surgery		-
EEL + Splenectomy	70 (28.3%)	
EEL + Other organ repair	16 (6.4%)	
Others	8 (3.2%)	
PCV transfused within 24 hours	93 (37.6%)	-
Length of hospital stay, days	7 (4-14)	1 (0.3%)
Mortality	35 (14.1%)	-

Continuous values are listed as median (interquartile range) and categorical variables as count (percentage).

EEL-Emergency exploratory laparotomy, FAST Focused assessment with sonography in trauma, CT computed tomography, PCV-packed cell volume, USG- Ultrasonography

26 (81%) of the grade 5 and 31 (67%) of grade 4 splenic injuries required operative management. 10 (17%) patients of grade 3 and only 3 (5%) patients of grade 2 injury required splenectomy. All the cases of Grade 1 splenic injuries were conservatively managed (Figure 3).

Fractures of the left sided ribs, along with a splenic injury, were not significantly associated with splenectomy. Injury severity score (ISS) was significantly higher in the patients undergoing splenectomy (Table 3).

**Table 3 Unadjusted Analysis (n=247)**

	No Splenectomy (n=177)	Splenectomy (n=70)	p Value	Odds Ratio (95% CI)
Age (years)	29	25	0.046	0.97 (0.95-1.0)
Males (%)	147 (81 %)	66 (94 %)	0.021	3.36 (1.12-9.94)
Blunt trauma (%)	169 (95 %)	70 (100%)	0.071	-
Intubated within one hour of arrival (%)	28 (16 %)	23 (32 %)	0.003	2.6 (1.37-4.94)
Transfusion within 24 hours of arrival (%)	54 (30 %)	39 (54 %)	<0.001	2.86 (1.62-5.06)
Grade 1 (%)	32 (18 %)	0	-	-
Grade 2 (%)	54 (30 %)	3 (4 %)	-	-
Grade 3 (%)	48 (27 %)	10 (14 %)	0.032	0.44(0.21-0.94)
Grade 4 (%)	15 (8 %)	31 (45 %)	0.000	8.58 (4.22-17.43)
Grade 5 (%)	6 (3 %)	26 (37 %)	0.000	16.84 (6.52-43.43)
Missing grade (%)	22 (12%)	0	-	-
Left sided rib fractures (%)	37 (20 %)	14 (20 %)	0.874	0.94 (0.47-1.88)
Vitals on arrival				
SBP (mmHg)	112	102	0.008	0.98 (0.97-0.99)
HR (bpm)	96	100	0.096	1.01 (0.99-1.02)
RR (/minute)	18	18	0.546	
SpO <sub>2</sub> (%)	97	93	0.024	0.97(0.90-1.05)
				0.97(0.94-0.99)
Injury severity score (ISS)	16	20	0.005	1.04 (1.01-1.08)
Time from injury to admission (minutes)	948	1239	0.565	-

## Lab investigations

Hemoglobin (mg/dL)	10.9	10.0	0.056	0.90 (0.82-1.00)
Hematocrit	21	25	0.147	1.01 (0.99-1.03)

Continuous variables are listed as mean and categorical variables as count (percentage).

SBP systolic blood pressure, HR heart rate, RR respiratory rate, mmHg millimeters of mercury, BPM beats per minute, SPO2 oxygen saturation.

Majority of patients in the splenectomy group had lower systolic blood pressure and oxygen saturation at arrival. More patients in the splenectomy group required transfusion within 24 hours of admission ( $p$  value  $<0.001$ ). A higher grade of splenic injury (grade 4 and grade 5) was associated with splenectomy ( $p$  value  $<0.001$ ). Male sex ( $p$  value 0.021) and requirement of intubation and mechanical ventilation within 1 hour of arrival ( $p$  value 0.003) were other significant predictors of splenectomy on unadjusted analysis.

## Discussion

The present study analysed the data of patients with splenic injury, admitted to four tertiary care hospitals in India, with the aim to assess how fractures of the left sided ribs, in cases with splenic injury, are associated with splenectomy. Thoracic injury was the most frequently encountered concomitant injury in patients with splenic trauma (45.7%). No significant association was noted between left sided rib fractures and splenectomy in the present study.

These findings do not support our initial hypothesis that fractures to the left sided ribs may result in a more severe splenic injury and thus more splenectomy. From our analysis we see that left sided rib fractures cannot be used to determine the need for splenectomy. Further research and studies primarily designed to investigate the association of fractures to bony cage protecting the abdomen with splenectomy are required before this can be said unequivocally.

In our study, a higher grade of splenic injury was significantly associated with splenectomy ( $p$  value  $<0.05$  for Grade 3 to 5 injuries). However, patient's conditions may necessitate an emergent transfer to the operating room without the opportunity to define the grade of the splenic lesions [25]. So, according to the recently published World Society of Emergency Surgery guidelines, the optimal strategy should take into consideration not only the grade of splenic injury but the patient's hemodynamic status and concomitant injuries as well (2).

Our study shows that systolic blood pressure and oxygen saturation levels on arrival were significantly associated with splenectomy on unadjusted analysis. We also observed that patients who required blood transfusions had higher odds of undergoing splenectomy on unadjusted analysis. Out of the 70 patients requiring splenectomy, 39 patients had received a blood transfusion within 24 hours of admission ( $p$  value 0.001). This finding corroborates many studies that have shown that the requirement of blood

transfusions is independently associated with splenectomy in cases of blunt abdominal trauma (2,15,26,27). We believe that unavailability of ICU beds, intensive care monitoring and blood and blood products, may have led to a lower threshold for splenectomy. In addition, lack of departmental protocols and surgeon biases may have led to splenectomies being performed despite a stable hemodynamic status and non-administration of blood transfusion.

Like in previous studies, we also observed that a higher ISS score was significantly associated with splenectomy on unadjusted analysis (28–30). However, ISS and other trauma assessment scores are usually used to analyze the outcomes in trauma patients and have little role in guiding patient management. The present study found splenic injury to be more common between the age of 20–50 years with a male preponderance. While lower age and male sex were significantly associated with splenectomy in unadjusted analysis, these findings are unlikely to be of any significance clinically.

## Limitations

A limitation of this study was the unavailability of data regarding the use of interventional radiological procedures like splenic artery embolization. An adjusted analysis was not performed due to the small sample size of patients undergoing splenectomy.

## Conclusion

In contradiction to our initial hypothesis, we found that left sided rib fractures were not significantly associated with splenectomy. Grade of splenic injury was an important determinant of splenectomy.

## Abbreviations

LMIC- Low- and Middle- Income Countries

TITCO- Towards Improved Trauma Care Outcomes

ICU - intensive care units

CECT- contrast enhanced computed tomography

PCV - packed cell volume

FAST - focused assessment with sonography in trauma

ISS – Injury Severity Score

## Declarations

*Funding:* The TITCO funding agencies were the Swedish National Board of Health and Welfare and the Laerdal Foundation. The authors declare that these agencies had no influence on the conceptualization or findings of this study.

*Conflicts of Interest:* Authors A.B, M.G.W, A.G, B.S, R.P, K.S, and M.K declare that they have no conflicts of interest to disclose.

*Ethics Approval:* Waiver of consent was obtained by all institutional review boards. The institutional ethics committee of all three participating hospitals LTMGH (IEC/11/13 dated 26 Jul 2013), KEM (IEC(l)/out/222/14 dated 4 Mar 2014) and SSKM (IEC/279 dated 21 Mar 2013) individually approved the collation of the database.

*Statement on Ethical Standard:* All procedures performed were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments.

*Consensus and Publication Statement:* This is a subgroup analysis of patients with splenic injury from the prospective trauma registry study named 'Towards Improved Trauma Care Outcomes' (TITCO) in India. [Roy N, Gerdin M, Ghosh S, et al (2016) 30-day in-hospital trauma mortality in four urban university hospitals using an Indian Trauma Registry. World J Surg 40:1299–1307]

This analysis and manuscript has not been published and is neither under consideration for publication elsewhere.

*Availability of data and materials:* The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

*Author Contributions:*

A.B, R.P and M.K conceptualized the study and also wrote the main manuscript text.

M.G.W, K.S supervised the statistical analysis and helped with the final draft of the manuscript.

A.G, B.S performed critical review of the manuscript and prepared the tables and figures of the manuscript.

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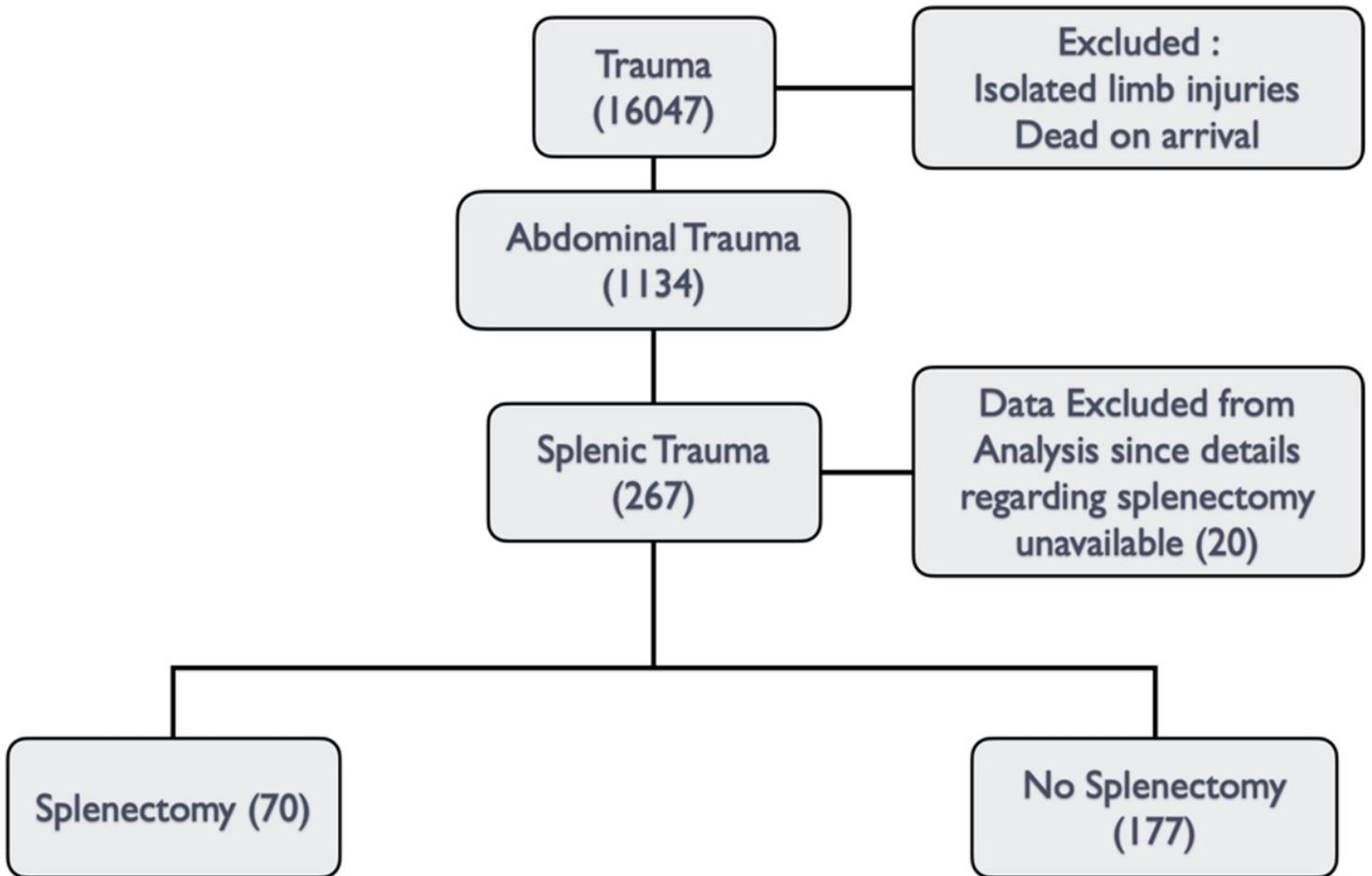
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## Figures



*Figure 1: Recruitment Algorithm*

Figure 1

Recruitment Algorithm

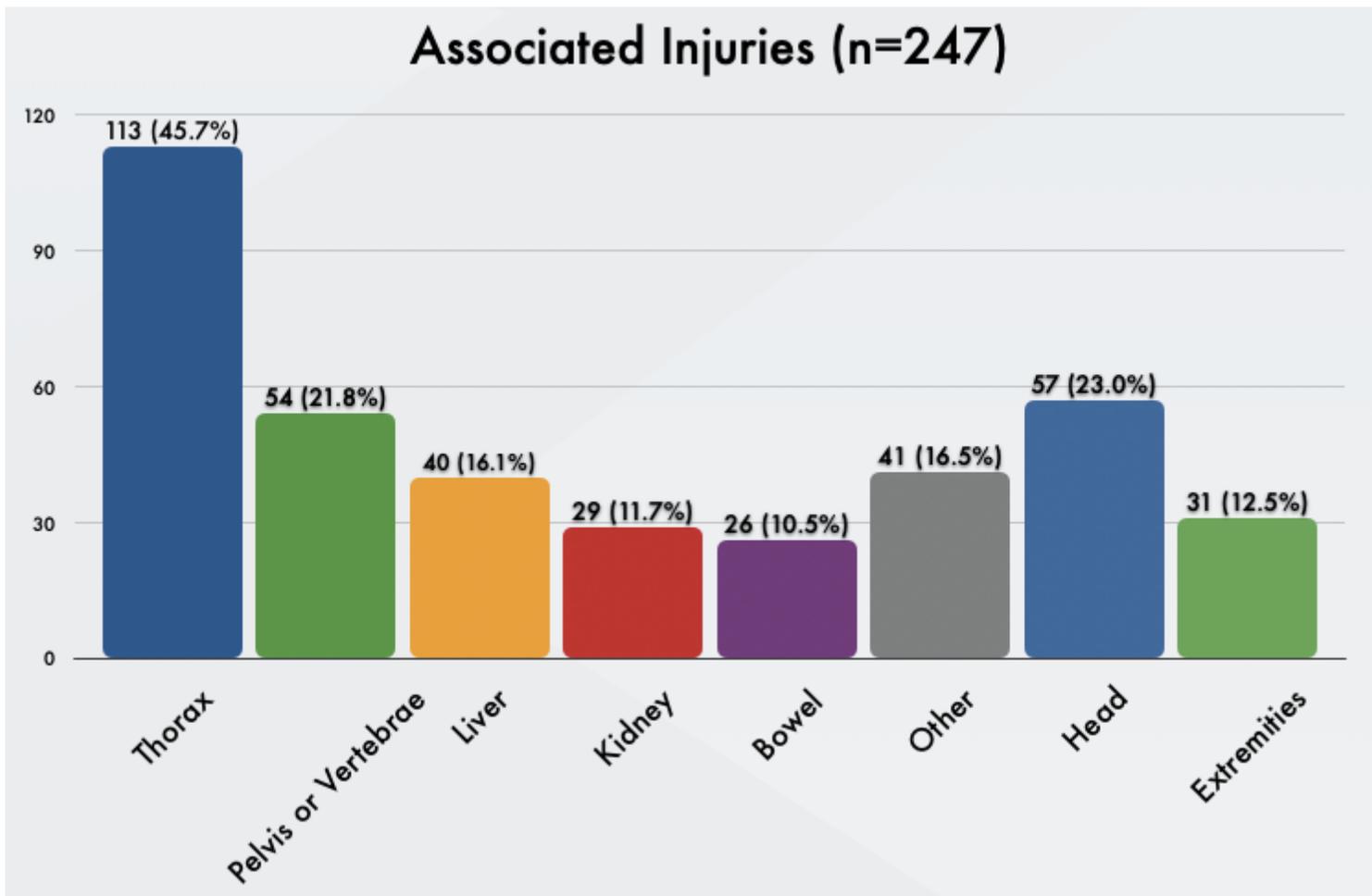


Figure 2

Associated Injuries

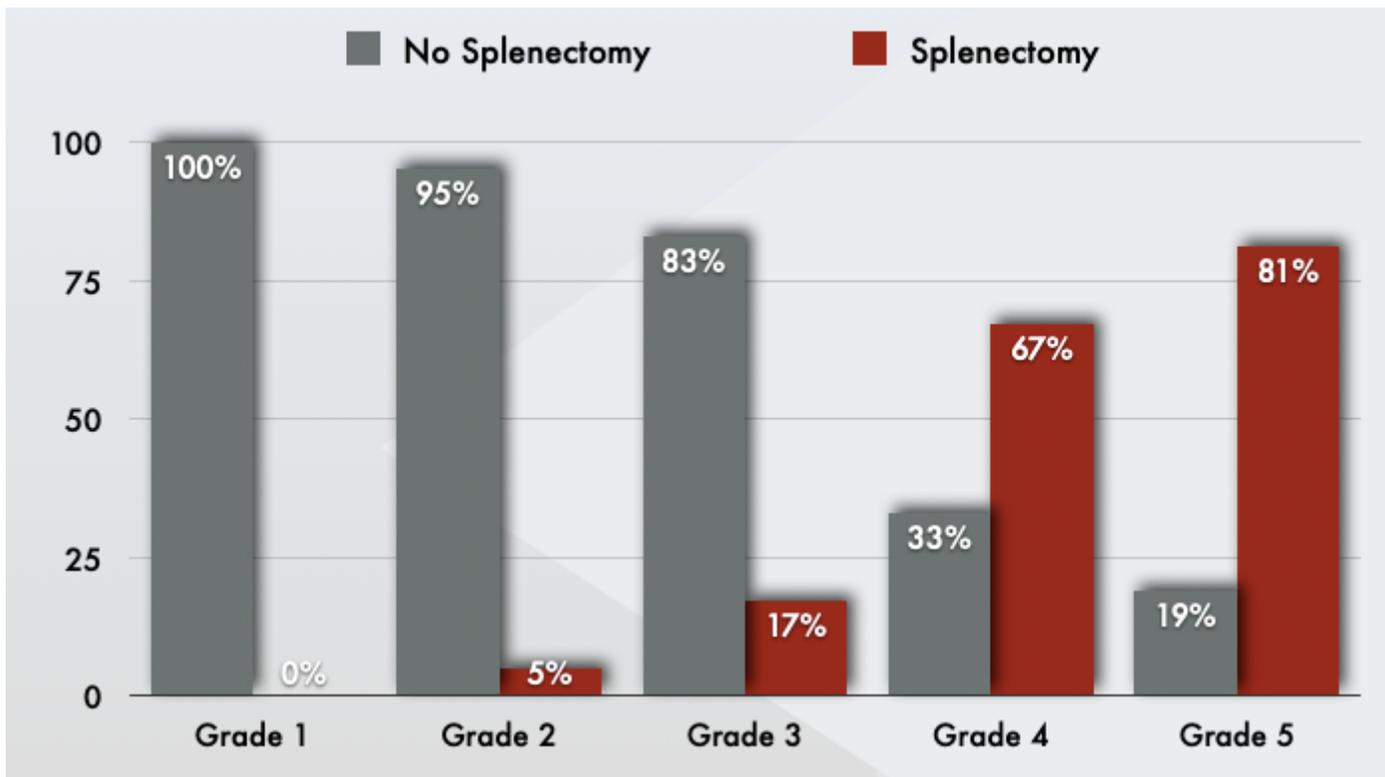


Figure 3

Association of splenectomy with grade of splenic injury