A review of the management of blunt splenic trauma in England and Wales: have regional trauma networks influenced management strategies and outcomes?

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ABSTRACT

INTRODUCTION The spleen remains one of the most frequently injured organs following blunt abdominal trauma. In 2012, regional trauma networks were launched across England and Wales with the aim of improving outcomes following trauma. This retrospective cohort study investigated the management and outcomes of blunt splenic injuries before and after the establishment of regional trauma networks.

METHODS A dataset was drawn from the Trauma Audit Research Network database of all splenic injuries admitted to English and Welsh hospitals from 1 April 2010 to 31 March 2014. Demographic data, injury severity, treatment modalities and outcomes were collected. Management and outcomes were compared before and after the launch of regional trauma networks.

RESULTS There were 1457 blunt splenic injuries: 575 between 2010 and 2012 and 882 in 2012–14. Following the introduction of the regional trauma networks, use of splenic artery embolotherapy increased from 3.5% to 7.6% ($P = 0.001$) and splenectomy rates decreased from 20% to 14.85% ($P = 0.012$). Significantly more patients with polytrauma and blunt splenic injury were treated with splenic embolotherapy following 2012 (61.2% vs. 30%, $P < 0.0001$). Increasing age, injury severity score, polytrauma and Charlson Comorbidity Index above 10 were predictors of increased mortality ($P < 0.001$). Increasing systolic blood pressure (odds ratio, OR, 0.757, 95% confidence interval, CI, 0.716–0.8) and Glasgow Coma Scale (OR 0.988, 95% CI 0.982–0.995) were protective.

CONCLUSIONS This study demonstrates a reduction in splenectomy rate and an increased use of splenic artery embolotherapy since the introduction of the regional trauma networks. This may have resulted from improved access to specialist services and reduced practice variation since the establishment of these networks.

KEYWORDS

Spleen – Abdominal injuries – Trauma centres

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Introduction

Abdominal trauma occurs in 7–10% of trauma patients, largely attributable to blunt trauma.¹ The organs most frequently injured by blunt abdominal trauma are the spleen and liver.² Costa *et al* investigated 844 patients from a single Italian centre, with both penetrating and blunt trauma, and who had at least one significant injury defined by either an injury severity score greater than 15 or abbreviated injury

score greater than 2.³ Forty-six percent of patients with abdominal trauma sustained splenic injury and mortality rates in this patient group were high (30%).³ The incidence of splenic trauma, its management and the associated mortality is currently unreported in the UK.

Emergency laparotomy with or without splenectomy remains the gold standard management for the haemodynamically unstable patient with blunt splenic injury.⁴

However, in an era of advancing interventional radiological techniques, there has been a recent transition toward splenic preservation through non-operative management of blunt splenic injury. The aim of such conservative management in the haemodynamically stable patient is to avoid unnecessary exploratory laparotomy (and associated morbidity), to maximise splenic salvage rates and reduce length of hospital stay. Splenic salvage is also advantageous in this patient group because of their relatively young age, requirement for lifelong antibiotic prophylaxis and avoidance of overwhelming post-splenectomy infection, which carries a 50–70% risk of mortality.^{5,6}

In the US, the Eastern Association for the Surgery of Trauma (EAST) has highlighted that the use of non-operative management for blunt splenic injury varies significantly according to the grade of splenic injury and severity of associated injuries, with less severely injured patients more likely to receive successful management without surgery and those with a higher injury severity score most likely to undergo emergency laparotomy with splenectomy.^{7,8} Studies have reported planned rates of non-operative management of 56.7–68.4%, with overall failure rates of 8.3–10.8%.^{7–9} Management can be by clinical observation alone or with splenic artery embolisation. Current worldwide practice

guidelines place little emphasis on the use of splenic angioembolisation for blunt splenic injuries and, as such, there is evidence of a variance in practice between trauma centres in the US.^{10,11}

In 2010, NHS England's trauma services in London underwent reorganisation following reports that highlighted variations in trauma service provision across the UK. In April 2012, regional trauma networks were launched outside London with the aim of improving survival and quality of life after major trauma through a combination of improved access to specialist services and improved systems.^{12,15} There are 20 adult/mixed major trauma centres, five paediatric centres and two major trauma collaborative centres (Manchester and Liverpool).

This study investigates the management and outcomes of blunt splenic injuries before and after the establishment of the English and Welsh Regional Trauma Networks in 2012.

Methods

The Trauma Audit and Research Network (TARN) is responsible for the national clinical audit for major trauma across England and Wales. All trauma patients arriving at the

Table 1 Associated abdominal injuries, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

	Splenectomy ± laparotomy <i>n</i> (%)	Laparotomy <i>n</i> (%)	Embolisation <i>n</i> (%)	No splenectomy, laparotomy or embolisation <i>n</i> (%)
<i>Group 1</i>				
<i>N</i>	115	58	20	382
Other abdominal injuries	27 (23.7)	27 (46.6)	0 (0)	61 (16)
Liver, pancreas, duodenum	11 (9.6)	17 (29.3)	0 (0)	26 (6.8)
Stomach, bowel, jejunum	6 (5.3)	5 (8.6)	0 (0)	0 (0)
Kidney	9 (7.9)	6 (10.3)	0 (0)	22 (5.8)
Vessels	3 (2.6)	3 (5.2)	0 (0)	9 (2.4)
Retroperitoneal bleeding	3 (2.6)	0 (0)	0 (0)	4 (1)
Mesentery	1 (0.9)	1 (1.7)	0 (0)	1 (0.3)
Bladder, urethra	0 (0)	2 (3.4)	0 (0)	1 (0.3)
<i>Group 2</i>				
<i>N</i>	131	87	67	597
Other abdominal injuries	28 (21.4)	50 (58.1)	14 (20.9)	87 (14.6)
Liver, pancreas, duodenum	14 (10.7)	22 (25.6)	5 (7.5)	47 (7.9)
Stomach, bowel, jejunum	5 (3.8)	14 (16.3)	0 (0)	1 (0.2)
Kidney	8 (6.1)	10 (11.6)	8 (11.9)	35 (5.9)
Vessels	6 (4.6)	10 (11.6)	3 (4.5)	8 (3.1)
Retroperitoneal bleeding	1 (0.8)	1 (1.2)	0 (0)	4 (0.7)
Mesentery	3 (2.3)	7 (8.1)	0 (0)	0 (0)
Bladder, urethra	3 (2.3)	4 (4.7)	0 (0)	1 (0.2)

emergency department alive and those transferred for specialist treatment, with a length of stay of 72 or more hours, critical care admission of any length or death in hospital are included in the audit.¹⁴ Injury-specific data, treatment, length of stay, critical care length of stay, outcome and pre-existing medical conditions are all recorded. All injury coding using abbreviated and injury severity scores was undertaken at TARN.¹⁴

A dataset was drawn from the TARN database of all patients who had suffered a splenic injury and were admitted in the 2 years before and after the establishment of regional trauma networks in 2012 (1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014). Data were retrieved on age, mechanism of injury, injury severity score, other injuries, management, length of hospital stay, length of stay in an intensive care unit and mortality. Polytrauma was defined as an abbreviated injury score of three or greater in more than one body region, based on the improved accuracy and reliability of this definition versus previous injury severity score-based definitions.^{15,16} Data were organised in Microsoft Excel® (Microsoft, Seattle,

Washington DC, US). Fisher's Exact and Chi-square tests were performed on categorical variables using GraphPad Prism (GraphPad Software Inc, California, US) and logistic regression analysis was performed to create a mortality prediction model using SPSS (IBM, New York, US). A *P* value of ≤ 0.05 was considered significant.

TARN has Health Research Authority ethical approval (section 251) for research on the anonymised data presented.

Results

From 1 April 2010 to 31 March 2014 there were 135,360 trauma admissions with known outcomes. Of these admissions, 1,572 patients (1.16%) were admitted with splenic trauma. Blunt splenic injury accounted for 1,457 of all splenic injuries (92.7%) while penetrating injury accounted for the remaining 115 admissions (7.3%). In 2010–12 (group 1), a total of 629 splenic injuries occurred, of which 575 were blunt splenic injuries. In 2012–14 (group 2), the total reported number of splenic injuries increased to 943, of

Table 2 Management of blunt splenic injuries, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

Treatment received	Splenectomy <i>n</i> (%)	Laparotomy, no splenectomy <i>n</i> (%)	Embolisation, no laparotomy or splenectomy <i>n</i> (%)	No embolisation, splenectomy or laparotomy <i>n</i> (%)
<i>Group 1</i>				
<i>N</i> = 575	115 (20)	58 (10)	20 (3.5)	382 (66.5)
Polytrauma	82 (71.3)	42 (72.4)	6 (30)	200 (52.4)
Mortality	8 (7)	11 (19)	2 (10)	35 (9.2)
PMC	67 (58.3)	30 (51.7)	11 (55)	264 (69.1)
Median:				
Age	32.3	33.1	32.6	30.6
ISS	29	34	18	24
LOS	13	15	9	8
LOS ICU	4	5	2	1
Spleen AIS severity	3	2	3	2
<i>Group 2</i>				
<i>N</i> = 882	131 (15)	87 (10)	67 (7.6)	597 (68)
Polytrauma	87 (66.4)	64 (73.6)	41 (61.2)	328 (66.5)
Mortality	18 (13.7)	18 (13.7)	4 (6)	56 (9.4)
PMC	93 (71)	93 (71)	40 (59.7)	387 (64.8)
Median:				
Age	32.6	37.5	41.7	34.0
ISS	29	34	25	24
LOS	10	18	10	8
LOS ICU	3	5	2	0
Spleen AIS severity	3	2	3	2

which 882 were blunt splenic injuries. Median age was 34.7 in group 1 and 34.1 in group 2, and median injury severity score was 25 in group 1 and 26 in group 2.

The proportion of patients who had suffered polytrauma (abbreviated injury score of ≥ 3 in more than one body region) was not significantly different between the groups (330/575, 57.4% vs. 520/882, 59.0%, $P = 0.55$). The distribution of other intra-abdominal injuries was also similar: liver/pancreas/duodenum/gallbladder 9.4% (54/575) in group 1 and 9.9% (88/882) in group 2; stomach/small bowel/colon 1.9% (11/575) in group 1 and 2.2% (20/882) in group 2; and kidney 6.4% (37/575) in group 1 and 6.9% (61/881) in group 2 (Table 1). There was no difference in the severity of splenic injury between the two time periods.

In group 1, 3.5% (20/575) of patients with blunt splenic injury were managed with angiography and embolisation compared with 7.6% (67/882) in group 2 ($P = 0.001$) (Table 2). There was no significant difference in the proportion managed by clinical observation alone (no intervention) between both groups (66.4% vs 67.7%, $P = 0.65$). The proportion of patients managed operatively (laparotomy $\pm$ splenectomy) was higher in group 1 compared with group 2 (30.1% vs 24.7%, $P = 0.025$; Fig 1). The splenectomy rate was also higher in group 1 (20% vs 14.85%, $P = 0.012$; Fig 2). The severity of splenic injury as described by the abbreviated injury score codes did not differ between the two time periods (Table 2).

Of the patients classified as having a blunt splenic injury and polytrauma, a significantly greater proportion were treated with embolisation after 2012 (61.2% vs 30%, $P < 0.0001$; Fig 3). The median injury severity score for patients treated with embolisation in group 2 was higher compared with group 1 (25 vs 18). Patients managed with laparotomy without splenectomy had the highest median injury severity score (34) and longest length of stay of all the treatment groups (Table 1). Overall, length of hospital stay and intensive care admissions were shorter in patients managed non-operatively across both groups (Table 2). Median length of stay following splenic artery embolisation was 9 days in group 1 and 10 days in group 2. In 2012–14, a

Figure 1 Operative vs non-operative management rates for blunt splenic injury, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

Figure 2 Splenectomy in patients with blunt splenic injury, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

Figure 3 Use of splenic artery embolisation in patients with polytrauma, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

significantly higher proportion of patients underwent splenectomy within 12 hours of admission (72.5% vs 60%, $P = 0.045$). The proportion of patients undergoing splenectomy over 24 hours after admission was 18.9% in group 1 versus 10.6% in group 2 ($P = 0.109$), no significant difference was observed in the number of patients undergoing splenectomy within an unknown time period ($P = 0.13$; Table 3).

The overall mortality associated with blunt splenic injury from 1 April 2010 to 31 March 2014 was 10.2% (149/1457). Mortality rates associated with blunt splenic injury for both time periods were not significantly different (9.7% in group 1 vs 10.5% in group 2, $P = 0.62$). While mortality rates following splenic artery embolisation in 2012–14 were lower than those in 2010–12 (5.9% vs 10%), statistical significance was not achieved ($P = 0.618$). Mortality rate following laparotomy was higher in group 2 (13.1% vs 9.9%) but this difference was not statistically significant ($P = 0.502$).

Logistic regression analysis identified increasing age, injury severity score, polytrauma and Charlson Comorbidity Index above 10 as strong predictors of mortality ($P < 0.001$). Laparotomy was associated with increased mortality risk

Table 3 Time to procedure, April 2010 to March 2012 (group 1) and April 2012 to March 2014 (group 2)

Time to procedure (hours)	Splenectomy <i>n</i> (%)	Laparotomy, no splenectomy <i>n</i> (%)	Embolisation, no laparotomy or splenectomy <i>n</i> (%)	No embolisation, splenectomy or laparotomy <i>n</i> (%)
<i>Group 1</i>				
<i>N</i>	115	58	20	382
0–12	69 (60)	35 (60.3)	10 (50)	–
13–24	4 (60.3)	2 (3.4)	4 (20)	–
> 24	17 (14.8)	6 (10.3)	1 (5)	–
Unknown	25 (21.7)	14 (24.1)	5 (25)	–
<i>Group 2</i>				
<i>N</i> = 882	131	87	67	597
0–12	95 (72.5)	51 (59.3)	32 (47.8)	–
13–24	6 (4.6)	1 (1.2)	2 (3)	–
> 24	12 (9.2)	12 (14)	13 (19.4)	–
Unknown	18 (13.7)	22 (25.6)	19 (28.4)	–

(regression coefficient, RC, 0.761, $P = 0.014$) but splenectomy alone offered a survival benefit (RC -0.718 , $P = 0.05$). Increasing Glasgow Coma Scale (GCS) and systolic blood pressure on arrival were found to be protective with every one unit increase in GCS equating to a 24% reduction in the odds of mortality and for every 10-unit increase in systolic blood pressure, a 12% reduction ($P \leq 0.001$). Admission following the establishment of major trauma centres did not have a significant effect on mortality prediction (Table 4). In addition, increasing the splenic injury grade from 3 to 5 did not significantly alter mortality risk (grade 3, $P = 0.832$, grade 4, $P = 0.749$, grade 5, $P = 0.274$).

Discussion

The reorganisation of major trauma services in England and Wales aimed to improve trauma care by increasing access to specialist teams and facilities and resolving service variation. An initial analysis performed by TARN suggests that the introduction of the regional trauma networks in April 2012 has resulted in improved overall survival following all major trauma in England (OR 2010, 1.2; 2013, 1.53).¹⁷

Our results demonstrate an increase in the total number of splenic injuries in 2012–14 compared with 2010–12. This may be explained by the improved hospital membership of TARN (an increase to 100% in April 2012 from 80% in April 2010) and is a concern from a methodological point of view. The authors would suggest that further study is necessary to assess for any true change in the incidence of blunt splenic injuries now that 100% hospital membership of TARN has been achieved. However, one must also consider the effects of best-practice tariffs, which incentivise consultant review within 5 minutes of arrival for injury severity score greater than 15, trauma management protocols and computed

tomography protocols, all of which may have improved splenic injury recognition and may have contributed to this potential increase.

We report equivalent survival in patients with a blunt splenic injury over both groups (group 1, 9.7%; group 2, 10.5%). This is an interesting finding, indicating that the changes in management associated with the establishment of regional trauma networks have not yet had an effect on mortality. However, the results do demonstrate a significant reduction in splenectomy rate (14.85% vs. 20%). Given that the proportion of patients managed conservatively did not differ significantly between the two groups (66.4% vs. 67.7%, $P = 0.65$), it is suggested that the increased use of angioembolisation may have contributed to the reduced splenectomy rate after 2012. One must also consider that trauma centres may provide improved patient selection, increased availability of intraoperative splenic conservation aids, such as topical haemostatic agents, and improved access to specialist services all of which may have contributed to the reduced splenectomy rate. The results demonstrate a significant increase in the use of interventional radiology after 2012, both in cases of isolated splenic injury ($P < 0.0001$) and in multiply injured patients with blunt splenic injury ($P < 0.0001$), suggesting that improved access to interventional radiology and improved expertise resulting from centralisation of services may be contributing to the improved rate of splenic preservation. Our results also suggest improved access to operating theatres, with 72.5% of patients requiring a splenectomy in theatre within 12 hours of admission compared with 60% of patients prior to 2012. While this may indicate improved theatre access, it may also represent an increased failure rate of non-operative management prior to trauma network introduction leading to a higher rate of delayed splenectomy.

Table 4 Logistic regression model for mortality

Variables	Regression coefficient	P value	Odds ratio	95 % confidence interval for odds ratio	
				Lower	Upper
Age	0.057	< 0.001	1.059	1.044	1.073
Injury severity score	0.064	< 0.001	1.066	1.046	1.086
Polytrauma	1.684	< 0.001	5.387	2.528	11.477
Grade:					
I	0	–	1	–	–
III	–0.076	0.832	0.927	0.458	1.873
IV	0.141	0.749	1.152	0.486	2.729
V	0.527	0.274	1.694	0.658	4.362
Missing	0.162	0.583	1.176	0.659	2.097
Other abdominal injuries	0.417	0.105	1.517	0.916	2.512
Post major trauma centres ^a	–0.129	0.597	0.879	0.544	1.42
Splenectomy	–0.718	0.05	0.488	0.238	1.001
Laparotomy	0.761	0.014	2.141	1.165	3.934
Angiography	0.706	0.338	2.046	0.478	8.585
Glasgow Coma Score	–0.279	< 0.001	0.757	0.716	0.8
Systolic blood pressure	–0.012	< 0.001	0.988	0.982	0.995
Charlson Comorbidity Index:					
0 (reference)	0	–	–	–	–
1–5	0.732	0.062	0.964	0.964	4.49
6–10	–0.923	0.405	0.045	0.045	3.484
> 10	2.249	< 0.001	2.834	2.834	31.685
Not recorded	1.036	< 0.001	1.647	1.647	4.824
Constant	–2.879	< 0.001	0.014	0.014	0.229

^a April 2012Hosmer-Lemeshow Chi square test 6.62, *P* = 0.5776

Area under the ROC curve 0.9362

The mortality associated with blunt splenic injury for the entire period studied (2010–14) was 10.2%. This is within values reported by previous studies (5.2–30%) in spite of including higher injury severity score.^{5,18} This study demonstrates that increased age, presence of polytrauma, increased injury severity score, a Charlson Comorbidity Index of greater than 10 and laparotomy were significantly associated with increased mortality risk. Higher Glasgow Coma Score and systolic blood pressure on arrival were associated with a reduced mortality risk, as was splenectomy alone. Surprisingly, changing the grade of splenic injury did not have any effect on the risk of mortality. Trauma centre establishment was also not associated with a change in mortality risk associated with blunt splenic injury.

Conclusion

This study demonstrates an increase in splenic conservation, as evidenced by a reduction in splenectomy rate, and increased use of splenic artery embolisation in the management of splenic trauma since the introduction of the major trauma networks in 2012. Data on splenic function following injury are not routinely collected as part of the TARN audit and should be considered as part of any subsequent prospective studies.

Current practice guidelines place little emphasis on the use of angioembolisation in blunt splenic injury management. The limited retrospective data presented in this article are insufficient for guideline development. We believe that

this topic warrants future prospective national study upon which guidelines for operative and non-operative management can be based.

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