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Abstract

Background

The non-operative management of splenic injury in children is widely recommended and possible in over 95% of cases. However, practice appears to vary between centres.

Method

The Trauma Audit and Research Network (TARN) database was interrogated to determine the management of isolated paediatric splenic injuries in hospitals in England and Wales. Rates of non-operative management, length of hospital stay, readmission and mortality were recorded. Management in paediatric surgical hospitals was compared to that in adult hospitals.

Results

Between January 2000 and December 2015 there were 574 cases. Children treated in a paediatric surgical hospital had a 95.7% rate of non-operative management compared to 75.5% in an adult hospital ($p < 0.0001$). A splenectomy occurred in 2.3% of children in hospitals with a paediatric surgeon and 17.2% in those treated in an adult hospital ($p < 0.0001$). There was a significant difference in the rate of non-operative management in children of all ages. There was some improvement in NOM in adult hospitals in the later part of the study, but ongoing significant differences remain.

Conclusion

The management of children with isolated splenic injury is different depending on where they are treated. The rate of non-operative management should be improved, particularly in hospitals without a paediatric surgeon present.

## Background

The importance of splenic preservation in children sustaining splenic injury is widely recognised, however reports continue to show variations in treatment depending on where children are managed and by whom[1-4].

There is evidence that the rate of non-operative management is higher if children are treated in dedicated paediatric centres and that those treated in adult trauma centres are more likely to be managed surgically [4-5].

The aim of this study was to determine whether a difference exists in England and Wales in the management of children with isolated splenic injury in paediatric hospitals and adult hospitals.

## Methods

The Trauma Audit and Research Network [TARN] was interrogated.[6] Children between the ages of 0 and 16 who had sustained isolated splenic injuries between January 2000 and December 2015 were identified. "Isolated" was defined as not having any other injuries that would affect management; those with Abbreviated Injury Scores (AIS) of 1 or 2 in other body regions were included [7].

The main study outcomes were the rate of non-operative management; blood transfusion; length of hospital stay; rate of readmission to hospital; and mortality in children managed in paediatric surgical compared to adult hospitals. Details of the injury were recorded and their severity scored, using the Abbreviated Injury Scale (AIS), based on imaging or operative findings[7]. The AIS grade of injury was determined by trained coders in the individual NHS trusts and verified by TARN. Information on re-admission to hospital has been routinely collected since October 2005. Outcome, in terms of survival or death, was based on assessment at discharge or 30 days, whichever was first.

Each hospital within the TARN database was assigned a status as either being a paediatric surgical centre or an adult centre. The definition of a paediatric surgical hospital was one in which there was an in-house paediatric surgeon on the full time staff. Adult hospitals were those who did not have a paediatric surgeon present. Outcomes were compared between children managed in adult and paediatric hospitals. Outcomes were compared in the early and later part of the study period (2000-2007; 2008-2015), and in different ages of children (0-10 years; 11-15 years)

Statistical tests were used to determine statistical significance, with a p value of $<0.05$ deemed statistically significant. Chi-square test and Fisher's exact test (if the numbers were small) were used for comparative data.

## Results

There were 574 isolated paediatric splenic injuries reported to TARN between January 2000 and December 2015.

There were 21 hospitals defined as paediatric surgical centres and 95 hospitals defined as adult. Of the 574 children, 301 were treated in paediatric centres and 273 were treated in adult centres. The demographics in terms of age, gender and the spread of severity of injury were comparable. (table 1) Blunt trauma accounted for 99.7% of all splenic injuries. The overall rate of non-operative management was 86.1%. Of eighty children who had an operation, 54 had a splenectomy, and 26 had spleen conserving surgery.

The rate of non-operative management was 95.7% in paediatric surgical hospitals, with a 2.3% splenectomy rate compared with 75.5% in adult hospitals ($p<0.0001$) with a 17.2% splenectomy rate ($p<0.0001$). The median length of stay was 5 days in adult hospitals compared to 7 days in paediatric hospitals. Re-admission rates were very low for both paediatric (0.2%) and adult (0.4%) centres. There were no deaths. (table 1)

Table 2 shows the number of patients treated operatively according to the grade of injury. Whilst the distribution of grade of injury was similar in those treated at adult and paediatric hospitals, the operative rates are markedly higher in adult hospitals for all grades of injury. Of note grade 5 injuries treated in paediatric hospitals had a higher non operative management rate (90.5%) than grade 2 injuries treated in adult hospitals. (86.3%). There were 11 children with grade 2 splenic injuries treated operatively in adult hospitals (13.7%).

The majority of children who underwent operative management did so within the first 24 hours after injury. (In adult centres 74.6%, paediatric centres 61.5% - table 3) Only 2.6% of children managed non-operatively received a blood transfusion, compared to 17.5% of children managed operatively. (table 4)

Young children (0-10) with splenic injury were managed non-operatively in 85.2% of cases in adult hospitals, compared to 95.1% in paediatric hospitals (p=0.026). In children aged 11-15, 70.6% were managed non-operatively in adult hospitals and 96.1% of cases in paediatric hospitals (p=<0.00001).

NOM and LOS were assessed at different historical time periods. The rate of NOM increased from 65.2% between 2000-2007 in adult hospitals to 78.9% between 2008-2015. In paediatric surgical centres the rate of NOM was similar in both time periods (96.4% vs 95.4%). The length of stay was longer in paediatric hospitals regardless of management, and length of stay was shorter between 2008-2015 compared to 2000-2007.

## Discussion

Until the 1960s most authorities recommended splenectomy for all children with traumatic rupture and cited mortality rates up to 100% if surgery was not promptly performed[8]. Knowledge of overwhelming post splenectomy infection (OPSI) increased and non-operative management gradually became the standard of care[9-10].

Several large studies have shown that over 95% of splenic injuries in children can be managed conservatively, even in those with severe injuries, with low morbidity and mortality[11-12]. However, the rate of surgical intervention varies significantly between centres [1-4,13-16.] Differences in management have been demonstrated between paediatric and adult centres, in trauma centres and in non-trauma centres, in rural and urban and in high volume compared to low volume centres[13-16.]

Our examination of the TARN database has shown a significant difference in the rate of non-operative management of splenic injury in children treated in paediatric surgical hospitals (95.7%) and adult hospitals (75.5%) in England and Wales between 2000 and 2015. A splenectomy occurred in 2.3% of children in hospitals with a paediatric surgeon and 17.2% in those treated in an adult hospital. There was a very low rate of readmission to hospital and there was no mortality in any child with an isolated splenic

injury in this 16-year period.

There has been an improvement in the rate of NOM in adult hospitals more recently (increasing from 62.5% to 78.9% between 2000-2007 and 2008-2015), however there is still a significant discrepancy and rates of NOM in paediatric surgical centres have been >95% throughout. The number of cases managed in adult hospitals compared to children's hospitals was similar despite there being far fewer paediatric hospitals (21 v. 95). The resultant increased case load in paediatric centres may have influenced decisions on management.

In this study a comparison of management was made for children in a paediatric surgical centre or an adult hospital that also looked after children. If there was at least one full time paediatric general surgeon present in the hospital it was designated as a paediatric surgical centre regardless of whether the centre was designated as a trauma centre by the Department of Health. During the study period a small number of hospitals changed status in our designation, due to staff and department moves, and this was taken into account in the analysis.

There was a trend towards more children having surgery greater than 24 hours after injury in paediatric hospitals compared to adult hospitals (38.5% vs 25.4%), and the rates of splenic salvage surgery were higher in paediatric hospitals (46.1% paediatric vs 29.8% adult). These results did not reach statistical significance but suggest that as well as more patients having non-operative management in paediatric centres, there may have been more patients who had a trial of NOM that was ultimately unsuccessful, and potentially a greater emphasis placed on splenic preservation. There were significant differences in the rate of non-operative management across all age groups but the most marked difference was in children between the ages of 11-15. We hypothesise that this is because adult surgeons are more likely to seek advice on management in younger children.

There are multiple controversies in the management of children with traumatic splenic injuries such as the use of blood products; the role of angio-embolisation; splenic salvage surgery and the optimal method of non-operative management including ICU

care, the length of stay in hospital for observation, bed rest and follow up imaging. Evidence based guidelines have been created and updated to best assess these parameters[17-20]. As a population based study, the reasons and decisions for non-operative/ operative management, and subsequent care were outside of the scope of this study.

The recommended LOS in hospital has decreased over the past 2 decades[17-20]. In this study children treated in both adult and paediatric centres were kept in hospital less time in the more recent time period after both operative and non-operative management.

This is the first study in the UK comparing management of isolated splenic injury in children. Children with splenic injuries, even those with severe injuries, can be managed conservatively with low morbidity and mortality. The management of trauma in the UK has changed in recent years. The introduction of Major Trauma Centres and Trauma Units across England and Wales began in 2012 and is now comprehensive. There are 27 trauma centres in NHS England and Wales where this study was conducted - 5 that purely manage children. Ideally children should be managed in dedicated high volume paediatric surgical hospitals but in practice adult general surgeons will often be involved in their care. It is important for all surgeons treating injured children to be competent in managing splenic injuries and to be aware that the vast majority children can be safely managed non-operatively regardless of the grade of splenic injury. An effort needs to be made to address the unsatisfactory management differences reported here between hospitals in England and Wales and to improve the current standard of care in all hospitals.

References

1. Mooney DP, Forbes PW. Variation in the management of pediatric splenic injuries in New England. *J Trauma.* 2004;56:328-333.

2. Davis, D.H., Localio, A.R., Stafford, P.W., Helfaer, M.A. & Durbin, D.R., 2005, Trends in operative management of pediatric splenic injury in a regional trauma system, *Pediatrics*, 115(1), pp. 89-94.

3. Keller, M.S. & Vane, D.W., 1995, Management of pediatric blunt splenic injury: comparison of pediatric and adult trauma surgeons, *Journal of pediatric surgery*, 30(2), pp. 221-224; discussion 224-225.

4. Mooney, D.P., Rothstein, D.H. & Forbes, P.W., 2006, Variation in the management of pediatric splenic injuries in the United States, *The Journal of trauma*, 61(2), pp. 330-333; discussion 333.

5. Adams, S.E., Holland, A. & Brown, J., 2017, Management of paediatric splenic injury in the New South Wales trauma system, *Injury*, 48(1), pp. 106-113

6. Lecky F. Twenty-five years of the trauma audit and research network: a continuing evolution to drive improvement. Emerg Med J 2015;32:906-908

7. Gennarelli TA, Wodzin E. AIS 2005: a contemporary injury scale. *Injury.* 2006;37:1083-1091

8. Stivelman, r.l., glaubitz, j.p. & crampton, r.s., 1963, Laceration of the spleen due to nonpenetrating trauma. One hundred cases, *American journal of surgery*, 106, pp. 888-891.

9. Holdsworth RJ, Irving AD, Cuschieri A. Postsplenectomy sepsis and its mortality rate: actual versus perceived risks. *Br J Surg.* 1991;78:1031-1038.

10. Dionne, B., Dehority, W., Brett, M. & Howdieshell, T.R., 2017, The Asplenic Patient: Post-Insult Immunocompetence, Infection, and Vaccination, *Surgical infections*, 2017 Jul;18(5), pp. 536-544

11. Davies DA, Pearl RH, Ein SH, Langer JC, Wales PW. Management of blunt splenic injury in children: evolution of the nonoperative approach. *J Pediatr Surg.* 2009;44:1005-1008.
12. Holmes JH, Wiebe DJ, Tataria M, et al. The failure of nonoperative management in pediatric solid organ injury: a multi-institutional experience. *J Trauma.* 2005;59:1309-1313.

13. Bowman, S.M., Zimmerman, F.J., Christakis, D.A., Sharar, S.R. & Martin, D.P., 2005, Hospital characteristics associated with the management of pediatric splenic injuries, *JAMA : the journal of the American Medical Association*, 294(20), pp. 2611-2617.

14. Knudson, M.M. & McGrath, J., 2007, Improving outcomes in pediatric trauma care: essential characteristics of the trauma center, *The Journal of trauma*, 63(6 Suppl), pp. S140-142.

15. Hsiao M., Sathya C., Mestral C., Langer J.C., Gomez D., and Nathens A.B.(2014) Population-based analysis of blunt splenic injury management in children: operative rate is an informative quality of care indicator. *Injury.* 45:5, 859-863

16. Li, D. & Yanchar, N., 2009, Management of pediatric blunt splenic injuries in Canada--practices and opinions, *Journal of pediatric surgery*, 44(5), pp. 997-1004.

17. Stylianos S. Evidence-based guidelines for resource utilization in children with isolated spleen or liver injury. The APSA Trauma Committee. *J Pediatr Surg.* 2000;35:164-167; discussion 167-169

18. St Peter SD, Sharp SW, Snyder CL, et al. Prospective validation of an abbreviated bedrest protocol in the management of blunt spleen and liver injury in children. *J Pediatr Surg.* 2011;46:173-177.

19. Notrica DM, Eubanks JW, Tuggle DW, et al. Nonoperative management of blunt liver and spleen injury in children: Evaluation of the ATOMAC guideline using GRADE. *J Trauma Acute Care Surg.* 2015;79:683-693.

20. Notrica DM, Eubanks JW, Tuggle DW, et al. Nonoperative management of blunt liver and spleen injury in children: Evaluation of the ATOMAC guideline using GRADE. *J Trauma Acute Care Surg.* 2015;79:683-693.

## Tables

Table 1 Demographics and management of splenic injuries in adult and paediatric surgical centres

| | **Adult centres** | **Paediatric surgical centres** | **P value** |
|---|---|---|---|
| **Total number** | 273 | 301 | |
| **Male gender** | 75.8% | 75.4% | |
| **Median age (IQR)** | 12.5 (9.7-14.4) | 12 (8.1-14.2) | |
| **Non-operative management n (%)** | 206 (75.5%) | 288 (95.7%) | p<0.0001 |
| **Operative management n (%)** | 67 (24.5%) | 13 (4.3%) | P<0.0001 |
| **Splenectomy n (%)** | 47 (17.2%) | 7(2.3%) | p<0.0001 |
| **Length of stay – median (IQR)** | 5 days (2-7) | 7 days (5-9) | |
| **Readmission to hospital** | 12 (0.4%) | 5 (0.2%) | p=0.08 |
| **Mortality** | 0 | 0 | |

Table 2: Comparing rates of non-operative management at different grades of injury (AIS) in adult and paediatric surgical centres. NOM= Non-operative management

| **Severity of injury** | **n = patients treated in adult centres** | **n = patients treated in paediatric centres** | **NOM in adult centres n (%)** | **NOM in paediatric centres n (%)** |
|---|---|---|---|---|
| **2** | 80 | 106 | 69 (86.3%) | 104 (98.1%) |
| **3** | 119 | 113 | 87 (73.1%) | 106 (93.8%) |
| **4** | 51 | 61 | 37 (72.5%) | 59 (96.7%) |
| **5** | 23 | 21 | 13 (56.5%) | 19 (90.5%) |
| **Overall** | 273 | 301 | 206 (75.5%) | 288 (95.7%) |

Table 3 Timing of Surgery after injury

| **Site type** | **Operation** | **n** | **%** | **p** |
|---|---|---|---|---|
| **Adult centres** | < 24 hours after injury | 50 | 74.6% | 0.33 |
| | >24 hours after injury | 17 | 25.4% | |
| **Paediatric surgical centres** | < 24 hours after injury | 8 | 61.5% | |
| | >24 hours after injury | 5 | 38.5% | |

Table 4. Proportion of patients receiving blood products

| **Management** | **Received blood products** | **n** | **%** |
|---|---|---|---|
| **NOM** | No | 481 | 97.4% |
| | Yes | 13 | 2.6% |
| **OM** | No | 66 | 82.5% |
| | Yes | 14 | 17.5% |

Table 5 Rate of NOM/OM at different age groups

| **Site type** | **Age (in years)** | **NOM** | | **OM** | |
|---|---|---|---|---|---|
| | | **n** | **%** | **n** | **%** |
| **Adult centres** | 0-10 | 75 | 85.2% | 13 | 14.8% |
| | 11-15 | 130 | 70.6% | 54 | 29.4% |
| **Paediatric surgical centres** | 0-10 | 116 | 95.1% | 6 | 4.9% |
| | 11-15 | 173 | 96.1% | 7 | 3.9% |

Table 6 Differences in NOM/ LOS depending on year of injury

| **Site type** | **Arrival year** | **Management** | **n** | **%** | **Median LOS (IQR)** |
|---|---|---|---|---|---|
| **Adult centres** | 2000-2007 | NOM | 45 | 65.2% | 4 (2-7) |
| | | OM | 24 | 34.8% | 7 (6-10) |
| | 2008-2015 | NOM | 161 | 78.9% | 4 (2-7) |
| | | OM | 43 | 21.1% | 6 (5-7) |
| **Paediatric surgical centres** | 2000-2007 | NOM | 80 | 96.4% | 9 (6-10) |
| | | OM | 3 | 3.6% | 11 (11-12) |
| | 2008-2015 | NOM | 208 | 95.4% | 6 (5-8) |
| | | OM | 10 | 4.6% | 7 (6-10) |