Original article

Management of blunt injuries to the spleen

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Background: **Non-operative management (NOM) of blunt splenic injuries is nowadays considered the standard treatment. The present study identified selection criteria for primary operative management (OM) and planned NOM.**

Methods: **All adult patients with blunt splenic injuries treated at Berne University Hospital, Switzerland, between 2000 and 2008 were reviewed.**

Results: **There were 206 patients (146 men) with a mean(s.d.) age of 38·2(19·1) years and an Injury Severity Score of 30·9(11·6). The American Association for the Surgery of Trauma classification of the splenic injury was grade 1 in 43 patients (20·9 per cent), grade 2 in 52 (25·2 per cent), grade 3 in 60 (29·1 per cent), grade 4 in 42 (20·4 per cent) and grade 5 in nine (4·4 per cent). Forty-seven patients (22·8 per cent) required immediate surgery. Transfusion of at least 5 units of red cells (odds ratio (OR) 13·72, 95 per cent confidence interval 5·08 to 37·01), Glasgow Coma Scale score below 11 (OR 9·88, 1·77 to 55·16) and age 55 years or more (OR 3·29, 1·07 to 10·08) were associated with primary OM. The rate of primary OM decreased from 33·3 to 11·9 per cent after the introduction of transcatheter arterial embolization in 2005. Overall, 159 patients (77·2 per cent) qualified for NOM, which was successful in 143 (89·9 per cent). The splenic salvage rate was 69·4 per cent. In multivariable analysis age at least 40 years was the only factor independently related to failure of NOM (OR 13·58, 2·76 to 66·71).**

Conclusion: **NOM of blunt splenic injuries has a low failure rate. Advanced age is independently associated with an increased failure rate.**

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Introduction

Non-operative management (NOM) of blunt splenic injuries has become the standard treatment of haemodynamically stable patients, irrespective of the degree of splenic injury. Recent studies have shown that NOM is attempted in almost two-thirds of all adult patients with success rates approaching 90 per cent[1–8].

The major impetus for preservation of the spleen has always been the risk of overwhelming postsplenectomy infection, with an estimated lifetime incidence of 2 per cent in adult splenectomized patients and an associated mortality rate exceeding 50 per cent[9–11].

The aim of the present study was to clarify the criteria for primary operative management (OM) and planned NOM, by comparing the characteristics of the two patient groups. An additional aim was to identify independent risk factors for failure of NOM.

Methods

All consecutive adult patients with blunt splenic injuries treated at the level I trauma centre of Berne University Hospital, Switzerland, between January 2000 and December 2008 were reviewed retrospectively. The study was approved by the institutional ethics committee and registered at ClinicalTrials.gov (registration number NCT00910182, http://www.clinicaltrials.gov).

Details of all trauma patients were prospectively and comprehensively recorded in the electronic data management system Qualicare™ (Qualidoc AG, Trimbach

Olten, Switzerland), which was introduced in 1998. Since 2007 the emergency department (ED) of Berne University Hospital has been an accredited site for the UK-based Trauma Audit Research Network. All trauma patients with an Injury Severity Score (ISS) above 7 are therefore included prospectively in the database by specially trained study nurses. To guarantee the most complete recruitment of patients, a review of all operative and discharge reports was undertaken.

All patients were managed and resuscitated according to Advanced Trauma Life Support (ATLS®; American College of Surgeons Committee on Trauma, Chicago, Illinois, USA) principles[12]. Haemodynamically unstable patients, those who failed to respond to fluid resuscitation and patients with a continued need for blood transfusion had surgery immediately. After the primary survey, patients who were haemodynamically stable underwent contrast-enhanced computed tomography (CT). The grade of splenic injury and the amount of haemoperitoneum were not considered exclusive or stringent criteria for surgery. Transcatheter arterial embolization (TAE) was introduced in May 2005 for stable patients with a splenic vascular blush or a splenic artery pseudoaneurysm seen on CT. Selective angiography of the coeliac artery and splenic artery was performed in these patients. After the site of bleeding had been identified, superselective embolization with Vortx® 18 microcoils (Boston Scientific, Natick, Massachusetts, USA) was performed.

Total splenectomy was the standard treatment for patients requiring OM. Organ-preserving procedures, such as splenorrhaphy, were considered only in young patients with isolated splenic injuries. The decision to perform laparotomy or to engage in NOM was made within 2 h after admission, usually after fluid resuscitation and CT.

The admission CT findings were reassessed by a surgeon and a radiologist who were blinded to patient management and outcome. The presence of a vascular blush or splenic artery pseudoaneurysm and the severity of splenic parenchymal injury according to the American Association for the Surgery of Trauma (AAST) grading were determined[13].

Trauma care setting

The level I trauma centre of Berne University Hospital receives more than 600 major trauma patients (ISS at least 16) per year. In the same area there are, however, three medium-sized regional hospitals that provide a 24-h surgical emergency service and handle the primary care of blunt splenic injuries.

Definitions

Isolated or near-isolated splenic injuries were considered as such if the splenic laceration was the only intra-abdominal injury and there were no major associated injuries that might significantly influence outcome. There were no associated injuries with an Abbreviated Injury Score (AIS) of 3 or more.

A simplified classification of the degree of haemoperitoneum was used[2]. A small haemoperitoneum was defined as perisplenic blood, blood in Morrison's pouch or the presence of blood in one or both pericolic gutters. A large haemoperitoneum was defined by the additional finding of free blood in the pelvis.

The response to fluid resuscitation was pivotal to the treatment decision. Fluid resuscitation was aimed at restoring blood pressure and organ perfusion in patients admitted with haemorrhagic shock. In accordance with the ATLS® guidelines, an initial 2-litre bolus of crystalloid fluid (warmed lactated Ringer's solution) was administered through a level I infuser. Depending on the estimated blood loss (results of Focused Assessment with Sonography for Trauma (FAST) examination, classification of haemorrhagic shock I–IV), early and robust blood replacement was performed (red cell transfusion, fresh frozen plasma). If necessary, additional crystalloids were given. The patient's status was constantly monitored and re-evaluated by measurement of blood pressure, pulse rate, central venous pressure, level of consciousness, respiratory rate, urinary output and peripheral perfusion. Immediate surgical intervention was undertaken if these measures did not result in a swift and stable reversal of the haemorrhagic shock.

The continued need for blood transfusion was a further factor influencing the treatment decision. Haemoglobin/haematocrit levels that continued to drop, or remained at a low level despite continued red cell transfusion, were regarded as a clear sign of continued bleeding even when the patient showed a good response to fluid resuscitation. Surgery was indicated if there was no major bleeding from concomitant injuries and CT revealed no splenic vascular contrast blush amenable to TAE. The decision to perform splenectomy needed to be taken early (within 2 h after admission, with no more than four red cell transfusions administered) in order to pre-empt the establishment of coagulation disorders that would be difficult to reverse.

Trauma scoring systems

The Revised Trauma Score (RTS) is based on three specific physiological parameters, each scored from 0 (severe impairment) to 4 (light impairment). It is scored from the first set of data obtained from the patient, comprising Glasgow Coma Scale (GCS), systolic blood pressure (SBP) and respiratory rate (RR). The RTS is calculated as $RTS = 0{\cdot}9368 \times GCS_{scored} + 0{\cdot}7326 \times SBP_{scored} + 0{\cdot}2908 \times RR_{scored}$. RTS values range from 0 to 7·84. The RTS has been shown to correlate well with the probability of survival[14].

The AIS is a simple numerical method for grading and comparing injuries by severity. The ordinal scale ranges from 1 (minor injury) to 6 (fatal injury). Scales for all anatomical regions and organs have been drawn up by the Organ Injury Scaling Committee of the AAST[15].

The ISS attempts to summarize the severity of injury in a patient with multiple trauma. It is defined as the sum of squares of the highest AIS grades in the three most severely injured body regions. Six body regions are defined: head and neck; face; chest; abdomen and visceral pelvis; bony pelvis and extremities; and external structures. The ISS ranges from 1 to 75. The ISS is a predictor for postinjury multiple organ failure and mortality[14].

The TRauma and Injury Severity Score (TRISS) combines anatomical (ISS) and physiological (RTS) scores of injury severity, taking into account the patient's age and differentiating between blunt and penetrating injury. TRISS has been shown to predict the probability of survival (as a percentage) following trauma[14].

In-hospital management and follow-up

There are no evidence-based guidelines for in-hospital management and follow-up of patients undergoing planned NOM[16]. In the present study, patients with an isolated or near-isolated splenic injury were admitted to an intermediate care unit with continuous monitoring during the first 24–48 h, depending on the degree of splenic injury and the amount of haemoperitoneum. Haemoglobin/haematocrit was measured between four and six times within the first 24 h, and daily thereafter. Bed rest was recommended for 1–7 days, depending on the degree of splenic injury and the amount of haemoperitoneum. Ultrasonography was usually performed within the first 48 h after admission in order to detect an increase in free intraperitoneal fluid. CT was carried out in selected patients (obese patients and those showing clinical deterioration or with higher degrees of splenic injury).

The duration of activity restriction after discharge from hospital depended on the degree of splenic injury and the intensity of the planned activity. It ranged from 4 weeks (AAST grade 1–2, light activity such as office work) to 12 weeks (AAST grade at least 3, strenuous activity such as construction work or playing soccer). Patients were followed up in the outpatient department. Ultrasonography or CT (for higher-degree splenic injuries) was performed routinely before resumption of normal activity (work, sport).

Statistical analysis

Continuous data are presented as mean(s.d.) with median. Normal distribution of data was tested using a normal QQ plot. The *t* test was used for analysis of normally distributed continuous data in two independent groups and the Mann–Whitney *U* test for non-normally distributed values. Fisher's exact test (two sided) or the χ^2 test was used to explore associations between categorical data in two independent groups. $P < 0{\cdot}050$ was considered statistically significant. A Bonferroni adjustment was performed in the case of multiple testing.

Risk factors for failure of NOM were assessed by univariable and multivariable logistic regression analyses. Failure of NOM was defined as the need for a delayed splenectomy. The dependent variables were represented by the choice of management (primary OM *versus* planned NOM) and the outcome of planned NOM (successful *versus* failed NOM). Potential risk factors influencing the dependent variables included: age, sex, time that trauma occurred (day *versus* night), mechanism of injury (traffic *versus* non-traffic related), setting of primary care (direct admission to level I ED *versus* initial evaluation at a regional hospital), fluid administration until admission, ED SBP, ED mean blood pressure, shock index (quotient of cardiac rate and systolic blood pressure), GCS, quantity of haemoperitoneum, isolated or near-isolated splenic injury, associated liver injury, American Society of Anesthesiologists (ASA) score, AAST classification, RTS, ISS, TRISS and number of red cell transfusions provided during the first 24 h after admission. All factors that were significant in univariable analysis ($P < 0{\cdot}050$) were entered into a multivariable stepwise regression model. Variables were then dropped from the full model one by one, starting from the variable with the highest *P* value. At each step of the regression, a likelihood ratio test was performed to make sure that reduced model of risk variables did not fit the data substantially less well than the full model. For each step the Hosmer–Lemeshow goodness-of-fit statistic was calculated to assess whether the values predicted by the model accurately represented the observed data.

Statistical analyses were performed with Stata® version 9 (StataCorp, College Station, Texas, USA).

Results

A total of 206 adult patients (146 men, 70·9 per cent) with blunt splenic injuries were identified. Their mean age was 38·2(19·1) (31·9) years, ranging from 16·1 to 88·0 years. The mean GCS score was 12·7(4·2) (15), with RTS 7·16(1·38) (7·84), ISS 30·9(11·6) (29) and TRISS 0·83(0·26) (0·96).

The following mechanisms of injury were recorded: motor vehicle crash (58 patients, 28·2 per cent), motorcycle crash (49, 23·8 per cent), fall (37, 18·0 per cent), sporting mishap (32, 15·5 per cent) and various others (30, 14·6 per cent).

The majority of accidents (144, 69·9 per cent) occurred between 08.00 and 20.00 hours. Most patients (150, 72·8 per cent) were transported directly to the ED of Berne University Hospital. The remainder were initially evaluated at regional hospitals. The overall mean interval between the accident and arrival at the ED of Berne University Hospital for all 206 patients was 135(124) (90) min. This interval was significantly shorter for the 150 patients transported directly to Berne University Hospital than for the 56 who were initially evaluated at a regional hospital: 101(102) (70) *versus* 240(130) (209) min ($P < 0·001$). Forty-two patients (20·4 per cent) were already intubated on arrival or required intubation immediately after admission. FAST was carried out in 182 patients (88·3 per cent), and revealed free intraperitoneal fluid in 135 (74·2 per cent). CT was performed in 190 patients (92·2 per cent). The remainder either underwent immediate surgery (10) or had CT at a later stage (6). In 18 patients (9·5 per cent) contrast medium extravasation was diagnosed by CT. TAE was attempted immediately after admission in 11 patients, and was successful in nine. There was no contrast medium extravasation in two patients, so no embolization was performed. One patient experienced delayed splenic rupture necessitating splenectomy on day 4 after successful TAE. The other ten patients were managed non-operatively. TAE was employed successfully on days 6 and 15 as a salvage procedure for delayed splenic rupture in another two patients undergoing NOM.

The AAST classification of the splenic injuries was grade 1 in 43 patients (20·9 per cent), grade 2 in 52 (25·2 per cent), grade 3 in 60 (29·1 per cent), grade 4 in 42 (20·4 per cent) and grade 5 in nine (4·4 per cent). The location and severity of associated injuries are summarized in *Table 1*.

Forty-seven patients (22·8 per cent) required immediate laparotomy (primary OM) because of haemodynamic instability or continued need for blood transfusions. Of these, 44 patients had a total splenectomy and three splenorrhaphy. The majority of patients (159, 77·2 per cent) were haemodynamically stable or responded to fluid resuscitation and therefore qualified for NOM, which was successful in 143 (89·9 per cent) and failed in 16 (10·1 per cent). Failure of NOM occurred a mean of 6·4(6·7) (4) days after the injury, with a range of 1–26 days. Five of 16 failures occurred on day 1. Fifteen patients experienced delayed splenic rupture while in hospital, between 1 and 13 days after admission. One patient suffered delayed splenic rupture after discharge from hospital, 26 days after the trauma. No initially missed intra-abdominal injuries (particularly enteric) were later revealed in patients managed non-operatively.

Table 1 Associated injuries and corresponding Abbreviated Injury Score in 206 patients with blunt splenic injury

	No. of patients*	Mean(s.d.) AIS
Head and neck	91 (44·2)	3·1(1·3)
Face	21 (10·2)	1·7(0·6)
Chest	140 (68·0)	2·9(0·9)
Abdomen and visceral pelvis (other than spleen)	80 (38·8)	2·8(0·8)
Bony pelvis and extremities	101 (49·0)	2·3(0·8)
External structures	46 (22·3)	1·5(0·5)

*Values in parentheses are percentages. AIS, Abbreviated Injury Score.

The higher the grade of splenic injury, the greater the percentage of patients needing immediate surgery and rate of failure of NOM (*Table 2*). The overall splenic salvage rate was 69·4 per cent (143 of 206).

Treatment modalities before (January 2000 to April 2005, 105 patients) and after (May 2005 to December 2008, 101 patients) the introduction of TAE were compared. The rate of primary OM decreased significantly from 33·3 per cent (35 of 105) to 11·9 per cent (12 of 101) ($P < 0·001$). Interestingly, there were no significant differences in the success rates of NOM in the two intervals (87 per cent, 61 of 70 *versus* 92 per cent, 82 of 89; $P = 0·439$).

Table 2 Failure rate of non-operative management of blunt splenic injuries in relation to American Association for the Surgery of Trauma severity grade of splenic injury

AAST splenic injury grade	No. of patients	Primary OM	Planned NOM	Failed NOM
1	43	4 (9)	39 (91)	1 (3)
2	52	10 (19)	42 (81)	3 (7)
3	60	11 (18)	49 (82)	6 (12)
4–5	51	22 (43)	29 (57)	6 (21)

Values in parentheses are percentages. AAST, American Association for the Surgery of Trauma; OM, operative management; NOM, non-operative management.

The mean length of hospital stay was 18·1(15·7) (14) days. This was influenced significantly by associated injuries. The trauma scores of patients with an isolated or near-isolated splenic injury were significantly more favourable than those of patients with a non-isolated splenic injury: ISS 25·3(8·4) (25) *versus* 37·4(11·6) (36), and TRISS 0·91(0·19) (0·97) *versus* 0·73(0·30) (0·88), respectively ($P < 0·001$). Eighteen (16·4 per cent) of 110 patients with isolated or near-isolated splenic injuries required primary OM, resulting in a hospital stay of 12·8(6·6) (11) days. The other 92 patients (83·6 per cent) qualified for NOM, which failed in eight patients (7·3 per cent) and was successful in 84 (76·4 per cent); length of hospital stay in these two subgroups was 21·6(12·7) (19) and 13·1(9·1) (11) days respectively. There was no significant difference in length of hospital stay between patients undergoing primary surgery and those who had successful NOM.

Four patients in the primary OM group succumbed to concomitant injuries (overall mortality rate 1·9 per cent).

Table 3 shows demographic data and characteristics on admission of patients undergoing primary OM and planned NOM. The corresponding information for patients with successful and failed NOM is shown in *Table 4*.

Table 3 Comparison of patients who had primary operative management with those who had planned non-operative management

	Primary OM ($n = 47$)	Planned NOM ($n = 159$)	P‡
Age (years)*	42·1(21·8)	37·0(18·0)	0·106§
Male sex	34 (72)	112 (70·4)	0·945
Daytime accident (08.00–20.00 hours)	35 (74)	109 (68·6)	0·553
Motor vehicle and motorcycle crash	27 (57)	80 (50·3)	0·483
Direct admission to level I ED	38 (81)	112 (70·4)	0·217
Emergency rescue helicopter transport	27 (57)	74 (46·5)	0·246
Time to arrival in ED (min)*	105(75)	145(134)	0·052§
Immediate intubation†	21 (45)	21 (13·2)	< 0·001
Fluid administered before admission (ml)*	1827(1178)	1414(966)	0·015§
ED systolic blood pressure (mmHg)*	113(26)	129(23)	< 0·001§
ED systolic blood pressure < 100 mmHg	14 (30)	8 (5·0)	< 0·001
Shock index ≥ 1	13 (28)	12 (7·5)	< 0·001
ED haematocrit (%)*	29·5(8·4)	35·9(6·8)	< 0·001§
Glasgow Coma Scale*	10·7(5·0)	13·3(3·8)	< 0·001§
Glasgow Coma Scale < 11	17 (36)	21 (13·2)	< 0·001
Large haemoperitoneum on CT/ultrasonography	30 (64)	70 (44·0)	0·026
Contrast blush on CT	9 (19)	9 (5·7)	0·010
Transcatheter arterial embolization	0 (0)	11 (6·9)	0·139
Isolated or near-isolated splenic injury	18 (38)	92 (57·9)	0·028
Associated liver injury	12 (26)	25 (15·7)	0·186
ASA score*	3·4(1·0)	2·8(0·7)	< 0·001§
AAST classification of splenic injury*	3·2(1·1)	2·5(1·1)	< 0·001§
Revised Trauma Score*	6·50(1·75)	7·34(1·19)	< 0·001§
Injury Severity Score*	33·8(13·5)	30·1(10·9)	0·055§
TRauma and Injury Severity Score*	0·70(0·32)	0·86(0·23)	< 0·001§
Red cell transfusion (units)*	8·7(8·5)	1·4(3·6)	< 0·001§
Length of hospital stay (days)*	23·8(23·6)	16·6(12·5)	0·006§
Death	4 (9)	0 (0)	0·002

Values in parentheses are percentages unless indicated otherwise; *values are mean(s.d.). †Intubation at the trauma site or immediately after arrival. OM, operative management; NOM, non-operative management; ED, emergency department; CT, computed tomography; ASA, American Society of Anesthesiologists; AAST, American Association for the Surgery of Trauma. ‡χ^2 test with Yates' correction for continuity, except §t test.

Predictors of the need for primary operative management

All significant predictors of the need for primary OM identified by univariable analysis are listed in *Table 5*. There were no significant associations between primary OM and sex, time of trauma, associated liver injury, mechanism of injury, primary care setting, mean SBP below 100 mmHg, fluid administration before admission exceeding 1500 ml, and ISS.

Significant factors associated with primary OM were included in a multivariable logistic regression model (*Table 5*). The likelihood ratio test suggested that the final model fitted the data well compared with the full model, and the Hosmer–Lemeshow test provided evidence that the final model was good at predicting the data ($P = 0·810$). Multivariable analysis showed that at least five red blood cell transfusions, GCS score below 11 and age 55 years or more were the only significant predictors associated with primary OM.

Predictors of failure of non-operative management

All significant factors for failure of NOM identified by univariable analysis are shown in *Table 6*. As age was the strongest predictive factor, several cut-off levels were evaluated for this variable. A cut-off at 40 years or more discriminated best in univariable analysis between failure and success of NOM (odds ratio (OR) 11·30; $P = 0·001$). Other less strong cut-off levels for age were 50 years or more (OR 5·78; $P = 0·001$) and at least 60 years (OR 2·32; $P = 0·183$). No significant associations were found with sex, ASA score, number of red blood cell transfusions, isolated or near-isolated splenic injury, splenic injury at night, associated liver injury, mechanism of injury, setting

Table 4 Comparison of patients with successful *versus* failed non-operative management

	Successful NOM (*n* = 143)	Failed NOM (*n* = 16)	*P*‡
Age (years)*	35·2(17·2)	53·5(16·9)	< 0·001§
Male sex	101 (70·6)	11 (69)	0·889
Daytime accident (08.00–20.00 hours)	96 (67·1)	13 (81)	0·381
Motor vehicle and motorcycle crash	71 (49·7)	9 (56)	0·813
Direct admission to level I ED	101 (70·6)	11 (69)	0·889
Emergency rescue helicopter transport	67 (46·9)	7 (44)	0·977
Time to arrival in ED (min)*	146(137)	121(62)	0·473§
Immediate intubation†	19 (13·3)	2 (13)	0·765
Fluid administration until admission (ml)*	1429(998)	1291(611)	0·589§
ED systolic blood pressure (mmHg)*	129(24)	124(15)	0·417§
ED systolic blood pressure < 100 mmHg	8 (5·6)	0 (0)	0·712
Shock index ≥ 1	12 (8·4)	0 (0)	0·480
ED haematocrit (%)*	36·0(6·9)	34·7(5·2)	0·467§
Glasgow Coma Scale*	13·3(3·7)	13·4(4·1)	0·919§
Glasgow Coma Scale < 11	19 (13·3)	2 (13)	0·765
Large haemoperitoneum on CT/ultrasonography	59 (41·3)	11 (69)	0·066
Contrast blush on CT	7 (4·9)	2 (13)	0·498
Transcatheter arterial embolization	10 (7·0)	1 (6)	0·679
Isolated or near-isolated splenic injury	84 (58·7)	8 (50)	0·688
Associated liver injury	22 (15·4)	3 (19)	0·994
ASA score*	2·8(0·7)	3·0(0·4)	0·264§
AAST classification of splenic injury*	2·4(1·1)	3·1(1·0)	0·016§
Revised Trauma Score*	7·34(1·18)	7·31(1·31)	0·924§
Injury Severity Score*	30·0(10·7)	30·4(12·2)	0·889§
TRauma and Injury Severity Score*	0·87(0·23)	0·76(0·25)	0·074§
Red cell transfusion (units)*	1·3(3·5)	2·9(3·4)	0·084§
Length of hospital stay (days)*	15·9(12·5)	23·2(10·9)	0·026§
Death	0 (0)	0 (0)	–

Values in parentheses are percentages unless indicated otherwise; *values are mean(s.d.). †Intubation at the trauma site or immediately after arrival. NOM, non-operative management; ED, emergency department; CT, computed tomography; ASA, American Society of Anesthesiologists; AAST, American Association for the Surgery of Trauma. ‡χ^2 test with Yates' correction for continuity, except §*t* test.

of primary care, mean blood pressure on arrival in the ED, GCS, amount of fluid administered before admission, RTS and ISS. The parameters SBP and shock index were removed from the analysis, as all patients with secondary failure of NOM presented with a blood pressure of at least 100 mmHg and a shock index below 1. Analysis by χ^2 test showed no statistical differences between the groups with successful and failed NOM: 12 of 143 *versus* 0 of 16 ($P = 0{\cdot}480$) for shock index at least 1; 8 of 143 *versus* 0 of 16 ($P = 0{\cdot}712$) for SBP below 100 mmHg.

Significant factors associated with the failure of NOM were included in a multivariable logistic regression model (*Table 6*). None of the factors was dropped from the full model, as the likelihood ratio tests indicated that the new models would fit the data less well than the full model. The multivariable analysis revealed that age 40 years or more was the only significant risk factor associated with failure of NOM in patients with blunt splenic injuries.

Table 5 Univariable and multivariable logistic regression analyses of factors for primary operative management

	Univariable OR	Multivariable OR
Age ≥ 55 years	2·10 (1·01, 4·38)	3·29 (1·07, 10·08)
ED systolic blood pressure < 100 mmHg	8·69 (3·35, 22·54)	1·40 (0·36, 5·46)
Shock index ≥ 1	5·03 (2·10, 12·08)	
Glasgow Coma Scale < 11	4·19 (1·98, 8·87)	9·88 (1·77, 55·16)
Large haemoperitoneum	2·24 (1·11, 4·53)	1·15 (0·34, 2·65)
Isolated or near-isolated splenic injury	0·45 (0·23, 0·88)	0·56 (0·21, 1·51)
ASA score ≥ 3	1·43 (1·04, 1·94)	
AAST classification ≥ 3	2·45 (1·22, 4·92)	1·92 (0·68, 5·46)
Revised Trauma Score < 7·5	4·21 (2·05, 8·63)	
TRauma and Injury Severity Score < 0·80	3·00 (1·45, 6·20)	1·65 (0·31, 4·92)
Red cell transfusion ≥ 5 units	14·20 (6·49, 31·07)	13·72 (5·08, 37·01)

Values in parentheses are 95 per cent confidence intervals. OR, odds ratio; ED, emergency department; ASA, American Society of Anesthesiologists; AAST, American Association for the Surgery of Trauma.

Table 6 Univariable and multivariable logistic regression analyses of risk factors for failure of planned non-operative management

	Univariable OR	Multivariable OR
Age ≥ 40 years	14·30 (3·12, 65·51)	13·58 (2·76, 66·71)
Large haemoperitoneum	3·06 (1·00, 9·27)	1·80 (0·47, 6·86)
AAST classification ≥ 3	3·50 (1·08, 11·37)	3·38 (0·82, 13·95)
TRauma and Injury Severity Score < 0·80	3·66 (1·16, 11·50)	3·70 (0·99, 13·86)

Values in parentheses are 95 per cent confidence intervals. OR, odds ratio; AAST, American Association for the Surgery of Trauma.

Discussion

A low failure rate was seen for NOM of blunt splenic injury. Surgeons seemed to select patients adequately for primary OM or planned NOM. Multivariable analysis identified age at least 40 years as the only risk factor associated with the failure of NOM.

The multi-institutional retrospective study of the Eastern Association for the Surgery of Trauma, which included almost 1500 adults with blunt splenic injuries of all AAST grades, showed that 38·5 per cent of all patients required primary OM. The remaining 61·5 per cent qualified for NOM, which was successful in 89·2 per cent[2]. A second retrospective study based on the American National Trauma Data Bank included more than 3000 patients with severe blunt splenic injuries (AAST grade at least 4). Primary OM was performed in 59·5 per cent and NOM was attempted in the remaining 40·5 per cent, with a success rate of 45·5 per cent[17]. The present data, based on patients with a similar ISS, compared favourably with the published benchmark. The primary OM rate was 22·8 per cent. NOM was attempted in the remaining three-quarters of patients and was successful in nine of ten.

Importantly, the study centre is a level I trauma hospital and as such a regional referral centre. Some selection of patients must have taken place, resulting from the fact that an unknown number of patients too unstable for transport were operated on in regional hospitals. This might have led to overestimation of the rate of successful NOM reported in the present study.

The identification of early predictors of the need for primary OM is important. Although NOM is considered to be the standard treatment of blunt splenic injuries, controversy exists about the selection of patients[18,19]. In the present series the low proportion of patients assigned to primary OM, combined with the low failure rate of NOM, underlines that patients were appropriately selected for NOM. The decision between primary OM and planned NOM was based on a hospital protocol, but the final treatment decision was left to the attending surgeon. A large number of red cell transfusions (at least five), a low GCS score (below 11) and advanced age (at least 55 years) were significant independent predictors of the need for primary OM. Interestingly, the AAST grade of splenic injury was not significantly associated with the decision to perform immediate surgery.

Nevertheless, the grade of splenic injury and the amount of haemoperitoneum are generally considered the strongest predictors of the failure of NOM[2–4,17,20]. In the present study there was a non-significant trend for a higher degree of splenic injury (AAST grade at least 3) as well as a lower TRISS (below 0·80) to be associated with failure of NOM, but advanced age (at least 40 years) was identified as the only independent risk factor. Several other authors reported age over 55 years to be associated with a higher failure rate and therefore considered advanced age a contraindication to NOM[3,8,21,22]. A Japanese study came to a similar conclusion and applied a threshold value of 60 years[19]. In contrast, other studies did not relate age over 55 years to a higher failure rate of NOM[4,7,23].

In NOM, admission to an intermediate care unit is advised for 24–72 h. Depending on the degree of splenic injury, continuous non-invasive cardiovascular monitoring on the ward should ensue. Failure of NOM occurred a median of 4 days after the injury, but with an upper range of 26 days. Predischarge ultrasonography or CT might allow discharge from day 7 onwards.

TAE has been reported to be a valuable adjunct in the NOM of blunt splenic injuries, increasing the splenic salvage rate[6,24–27]. Most studies recommend selective use of TAE, limited to patients with a contrast blush[28,29] or a post-traumatic splenic artery pseudoaneurysm on CT[6], in order to avoid unnecessary angiography-related complications[30]. In the present study, TAE was used only in patients with a contrast blush on CT, either immediately after admission or as a salvage procedure during delayed splenic rupture. No clinically relevant complications occurred. The majority of patients with blunt splenic injury, however, were managed with observation alone, in particular during the first 5 years of the present series when TAE was not available.

The overall splenic salvage rate was considerable in patients selected for NOM of blunt splenic injury. NOM failed in about one in ten patients selected for this care pathway. Advanced age was associated with an increased failure rate of NOM in patients with blunt splenic injuries, a finding that might influence in-hospital management and follow-up for this group of patients at higher risk of delayed splenic rupture.

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