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No Further Incidence of Sepsis after Splenectomy for Severe Trauma: A Multi-institutional Experience of The Trauma Registry of the DGU with 1,630 Patients

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Abstract

Objective: Non-operative management of blunt splenic injury in adults has been applied increasingly at the end of the last century. Therefore, the lifelong risk of overwhelming post-splenectomy infection has been the major impetus for preservation of the spleen. However, the prevalence of posttraumatic infection after splenectomy in contrast to a conservative management is still unknown. Objective was to determine if splenectomy is an independent risk factor for the development of posttraumatic sepsis and multi-organ failure.

Methods: 13,433 patients from 113 hospitals were prospective collected from 1993 to 2005. Patients with an injury severity score >16, no isolated head injury, primary admission to a trauma center and splenic injury were included. Data were allocated according to the operative management into 2 groups (splenectomy (I) and conservative managed patients (II)).

Results: From 1,630 patients with splenic injury 758 patients undergoing splenectomy compared with 872 non-splenectomized patients. 96 (18.3%) of the patients with splenectomy and 102 (18.5%) without splenectomy had apparent infection after operation. Additionally, there was no difference in mortality (24.8% versus 22.2%) in both groups. After massive transfusion of red blood cells (>10) non-splenectomy patients showed a significant increase of multi-organ failure (46% vs. 40%) and sepsis (38% vs. 25%).

Conclusions: Non-operative management leads to lower systemic infection rates and mortality in adult patients with moderate blunt splenic injury (grade 1-3) and should therefore be advocated. Patients with grade 4 and 5 injury, patients with massive transfusion of red blood cells and unstable patients should be managed operatively.

Key words: blunt abdominal trauma, splenic injury, splenectomy, transfusion, sepsis, mortality

Introduction

The incidence of abdominal trauma in patients with multiple injuries is approximately 20% in Europe, with blunt injuries accounting for 95% of cases. The solid organs are most frequently affected, with spleen lesions playing a prominent role in the diagnostic and therapeutic management of the blunt abdominal trauma, as they account for approximately 50% of all injuries to abdominal organs [1, 13, 27, 31].

During the last 15 years, non-operative management of spleen injuries has been clearly demonstrated to be an effective therapeutic option. Six factors predict the failure of non-operative management: hemodynamic instability, preexisting splenic disease, age older than 55 years, grade of injury, size of the hemoperitoneum and contrast blush on CT (computer tomography) scans [7, 11, 17]. Pachter et al commented in his work that patients with grade 4 and 5 injuries were successfully managed non-operatively. The concept of a spleen-sparing therapy for traumatic injuries has gained importance over recent years, because of rare, but nonetheless possible severe septic postoperative complications. According to several studies, the risk of developing an infection is correlated with the reason for splenectomy and the age of the patient, with the majority of infections occurring years after splenectomy [4, 14, 19, 28]. The lifelong risk of overwhelming post-splenectomy infection (OPSI) has been one of the major impetus for preservation of the spleen. However, the prevalence of posttraumatic infection after splenectomy in contrast to a conservative management is still not really known. Some reports and studies refer of higher infection rates after splenectomy in children and adults [10, 16, 18]. But up to now there are no analyses in large patient collectives which altercate with posttraumatic patients against the trauma grade and transfusion of PRBC (Packed Red Blood Cells).

Nonetheless, other authors demonstrated a significantly increase in the risk of failure with splenic injuries [24, 25]. Bleeding, the most common cause of failure can occur at any time of hospitalization. The question remains, whether the non-operative management is always a benefit of the patient? Particularly in consideration of the fact, that potential postoperative risk on the Intensive Care Unit (ICU) such as a major bleeding is disproportionate to the consequences of splenectomy.

Currently, little is known what effect splenectomy for trauma has on early postoperative infectious complications. It was the aim of the present study to evaluate the infection and MOF rate among 758 patients following splenectomy for multiple traumas compared to 872 patients with non-operative management, based on prospective collected data from The Trauma Registry of the DGU (TR-DGU).

Patients and Methods

From 1993 until 2005, 13,433 patients from 113 hospitals were documented prospectively in TR-DGU. It is a prospective, standardized and anonymized documentation of severely injured patients at defined time points. This documentation of the clinical course includes the first examination at the accident site (time point A), hospital admission (time point B), transfer to ICU (time point C), and discharge from hospital (time point D), together with possible complications (sepsis, organ failure, death) and anatomical and physiological parameters [21]. In this analysis the following eligibility criteria were used:

1. Injury Severity Score (ISS) ≥16
2. Direct admission to a trauma center
3. Splenic injury

Injury Severity Score (ISS) and the severity of individual injuries were determined with the 1998 revision of the Abbreviated Injury Scale (AIS). The AIS is a globally accepted classification system. The classification is based on body regions and each injury is represented by a 7 digit code. The last digit of the code characterizes the injury severity, using a scale ranging from 1 to 6. AIS 1 represent a minor injury and AIS 6 an injury untreatable according to the latest scientific knowledge, leading mostly to a direct fatal outcome. Splenic injuries are graded according to the injury scale of the American Association for the Surgery of Trauma (AAST), Table 1. In the present study, the AIS spleen of the Association for the Advancement of Automotive Medicine (AAAM) was chosen as the scale to describe the severity of splenic injury.

Sepsis was defined by the criteria of Bone et al. [3]. The definition of organ failure followed the SOFA score (Sequential Organ Failure Assessment); where an individual organ failure was defined by at least 3 SOFA score points; a multi-organ failure (MOF) was defined as simultaneous failure of at least two organs [29].

All patients with a spleen injury (AIS spleen 2-5) were assigned to the "spleen trauma" group. All remaining patients without spleen injury (AIS spleen 0) were placed in the "non-spleen trauma" group.

The restriction to cases with ISS ≥16 guaranteed a minimum injury severity of AIS 3 for the primary region in the respective study groups.

In order to assess the risk of death based on the initial severity of injury, a prognosis was made using the Revised Injury Severity Classification (RISC). Until 2003, TR-DGU has been using the TRISS Score, an internationally-spread score system for the prognosis of trauma patients based on the American MTOS study. Some studies on prognostically relevant factors in trauma as well as criticism by other authors concerning TRISS have lead to the development of a new severity classification system for the prognosis of outcome, using the data of TR-DGU. With data of more than 2000 patients and multivariate statistical modeling, the RISC has been developed and repeatedly validated within the register. The RISC takes into consideration: the age, the anatomical pattern of injuries (New ISS), the head injury, the severe pelvis trauma, coagulation (PTT), the base excess, three indirect signs of bleeding (hypotension, low hemoglobin, mass-

Table 1. AAST-scale and modified scale for classification of spleen injuries.

AAST Grade	Injury	Injury Description	AIS-98* Grade
I	hematoma	subcapsular, <10% surface	2
	laceration	capsular tear, <1cm	2
II	hematoma	subcapsular, 10–50% surface; intraparenchymal hematoma, <10cm in diameter	2
	laceration	1–3cm deep, <10cm long	2
III	hematoma	subcapsular, >50% surface; intraparenchymal hematoma, >10cm	3
	laceration	>3cm parenchymal	3
IV	laceration	parenchymal disruption involving 25–75% of spleen	4
V	laceration	parenchymal disruption involving >75% of spleen	5
	vascular	splenic venous injuries	5
VI	vascular	splenic avulsion	6

*Note–AIS-98 = Abbreviated Injury Scale, 1998 version.

transfusion) as well as cardiac arrest. Comparable analysis have shown that the RISC is significantly superior to the scores (e.g. TRISS) used so far. Since 2003, the RISC is being used as main instrument for severity adjustment and outcome analysis [8, 22].

Statistics

From 1993 until 2001, data were collected and entered on paper sheets. Since 2002, data collection was done with internet-based data entry software with integrated plausibility checks. The anonymized data were analyzed with the statistical software SPSS (Version 14, Chicago, USA). Incidences are presented with counts and percentages, continuous values with mean and standard deviation (SD). Analysis was mainly restricted to descriptive statistics. Statistical tests were avoided due to the multiple comparisons (several groups and outcome parameters), as well as the high sample size which could lead to irrelevant significances. In selected situations only, data from the group with spleen trauma were compared statistically against the remaining groups (Chi^2 test for incidence rates and U-test for continuous values).

Results

From 1993 to 2005, a total of 13,433 emergency room patients with an ISS ≥16 points were included in TR-DGU, of whom 1,630 (12.1%) matched the inclusion criteria of the present study. Of these, 295 (18.1%) had splenic lesions classified as AIS spleen 2, 457 (28.0%) as AIS spleen 3, 485 (29.8%) as AIS spleen 4 and 393 (24.1%) as AIS spleen 5 were identified. Laparotomy with splenectomy was required in 758 (46.5%) patients with splenic injury. 32 (10.8%) splenectomies of AIS spleen 2, 106 (23.2%) of AIS spleen 3, 316 (65.2%) AIS spleen 4 and 304 (77.4%) of AIS spleen 5 were performed, Table 2. Average age in the total sample was 35.38 years and 71.3% of the included subjects were male. The mean ISS was 38.94 points.

Mortality

Mortality after splenectomy was slightly increased (24.8%) compared to patients without splenectomy (22.2%), Table 3. Supporting analysis of these results between the splenectomized and the non-splenectomized patients showed that the comparable mortality is explained almost by the same, without being equal: AIS scores head: 37.7% vs. 43.9%, thorax: 74.8% vs. 78.0% and extremities: 46.2% vs. 47.1%. Adjusting for severity with the RISC Score shows that patients with splenic injury do not die more frequently than expected. The 25.0% mortality observed (95.0% confidence interval 27.6 – 38.4) in the patients after splenectomy offsets a prognostic mortality rate of

Table 2. Data analyses of splenic injured patients indexed by AIS spleen and followed treatment option, splenectomy or non-splenectomy.

AIS spleen	Patients		Splenic Injury		Splenectomy		Non-Splenectomy	
	n	%	n	%	n	%*	n	%*
0	11,803	87.9	0	0	0	0	0	0
2	1,630	12.1	295	18.1	32	10.8	263	89.2
3			457	28	106	23.2	351	76.8
4			485	29.8	316	65.2	169	34.8
5			393	24.1	304	77.4	89	22.6
total	**13,433**	**100**	**1,630**	**12.1**	**758**	**5.6**	**872**	**94.4**

*%/max AIS spleen

Table 3. General data analyses of studied splenic injured patients indexed by treatment option.

	Unit n = 758	Splenectomy n = 872	Non-Splenectomy
ISS	points	41.6	36.5
Age	years	36.5	34.4
Male	%	71.4	71.3
Mortality	%	24.8	22.2
AIS head ≥3	%	37.7	43.9
AIS thorax ≥3	%	74.8	78.0
AIS extremities ≥3	%	46.2	47.1
ICU	days	16.9	16.3
Hospital stay	days	31.4	28.7

26.7% (SMR 0.94). Patients without splenectomy showed a slightly lower mortality rate compared with patients after splenectomy (Mortality 21.5, RISC 23.0, SMR 0.94). In both groups of injuries, prognosticated mortality did not deviate from the observed mortality, Table 4. Even more, the prognosticated mortality was lower in splenectomized than in non-splenectomized patients. Consequently, there was a lower overall mortality after splenectomy. At the same time, the subanalysis carried out shows that non-splenectomized patients with AIS score 2-3 have lower mortality rates – patients with AIS spleen score 4-5 have significantly worse rates however – than patients after splenectomy, Table 5. The same results are shown considering the sepsis and MOF-rates.

Blood Transfusion and Incidence of Shock

Splenectomized patients had a higher need for massive blood transfusions (number of transfused PRBC >10), (31.9% vs. 19.5%), Table 4. The high blood loss in the splenectomy group is correlated with the blood pressure pattern in the emergency room (ER). Initial blood pressure ≤90mmHg was 31.7% in of the splenectomy group and 25.9% of the non-splenectomy group. In the ER, an initial hemoglobin content of less than 9mg/dl was much more frequent in the splenectomy group (42.6%) than in the non-splenectomy group (31.7%). Analogous to this, the average amount of transfused PRBC until admission to the intensive care unit was much higher in the group of patients with splenectomy (8.5 units) compared to the non-splenectomy group (5.0 units).

Sepsis and Organ Failure

Both groups nearly showed the same mortality after 24 hours (14.1% vs. 13.5%). Furthermore, patients with a splenectomy showed near by the same average late mortality of 24.8% as those without splenectomy 22.2%. One cause for the comparable mortality in comparison with patients with non splenectomy is possibly the same sepsis rate (18.3% vs. 18.4%), if the first 24 hours were survived, Table 4. The assimilable sepsis rate in both groups is also reflected in the frequency of OF (53.0% vs. 45.6%) and MOF (33.4% vs. 29.0).

As presented in Table 5, the above described separation of patients in dependence of the AIS spleen scores is shown. Non-splenectomy patients with an

Table 4. Blood transfusion, sepsis and mortality analyses of studied splenic injured patients.

	Unit	Splenectomy n = 758	Non-Splenectomy n = 872
PRBC	units	8.5	5.0
>10 PRBC	%	31.9	19.5
RR ≤90mmHg (ER)	%	31.7	25.9
Hb <9mg/dl	%	42.6	31.7
Organ failure	%	53.0	45.6
Multiple Organ Failure	%	33.4	29.0
Sepsis	%	18.3	18.4
Mortality within 24 hours	%	14.1	13.5
		n = 711	n = 805
Mortality	%	25.0	21.5
RISC	%	26.7	23.0
SMR	%	0.94	0.94

Table 5. Mortality by AIS spleen and treatment group when survived.

AIS spleen	Splenectomy	N	ISS	OF (%)	MOF (%)	Sepsis (%)	Mortality (%)
2	Yes	32	32.4	76.5	71.6	26	19
	No	263	31.2	47.7	30.6	17	12
3	Yes	106	33.4	72.7	53.2	26	23
	No	351	35.1	56.6	35.9	20	19
4	Yes	316	39.5	64.4	43.0	18	21
	No	169	39.7	67.8	41.1	20	25
5	Yes	304	47.9	76.0	41.0	16	30
	No	89	52.1	96.0	72.2	88	58

Table 6. When survival after 24 hours and more then 10 PRBC.

	ISS	PRBC	OF (%)	MOF (%)	Sepsis (%)	N
Splenectomy	42.7	18.7	64	40	25	125
Non- Splenectomy	40.4	18.6	59	46	38	95

AIS spleen 2-3 show lower sepsis as well as OF- and MOF-rates as patients after splenectomy. With a spleen score of 4 and 5 however, this is just the other way around: sepsis-, OF- and MOF-rates are significantly better than after conducted splenectomy.

In order to assess, whether an increased administration of PRBC has an influence on sepsis-, MOF- and/or OF-rates, a subgroup was formed consisting of "only" transfused patients with ≥10 units who survived the first 24 hours. The results in this subgroup are displayed in Table 6. With an almost identical administration of PRBC in splenectomy patients (n = 125) as well as non-splenectomy patients (n = 95) – units 18.7 vs. 18.6 – significant differences in the sepsis- (25% vs. 38%) and MOF-rate were shown. Consequently, only severely injured patients seemed to profit from operative care.

Discussion

The modern era for splenic surgery for starts 1892 when Riegner reported a splenectomy in a 14-year old worker after blunt trauma. This report set the stage for routine splenectomy, which was performed for all splenic injury in the next generations. Despite early reports by Pearce and by Morris and Bullock that splenectomy in animals caused impaired defenses against infection, little challenge to routine splenectomy was made until King and Schumacker in 1952 reported a syndrome of OPSI [12]. Many studies have since demonstrated the importance of the spleen in preventing infections, particularly from the encapsulated organisms. The most serious of these infections is the syndrome of OPSI, which occurs rarely (0.5%) in adults subjected to splenectomy but carries a prohibitive mortality in unvaccinated patients. Therefore, the preservation of the spleen and the shift form conventional operative management to selective non-operative management of blunt splenic trauma injuries has shown a noticeable trend varied from 53% to 77% in the past decade with failure rates generally ranging from 2% to 11% [9, 15, 20]. Increasing awareness of the risk of OPSI and postoperative complications were the major incentives for the concept of a spleen-sparing therapy for traumatic injuries. The precise incidence of OPSI after splenectomy for trauma remains controversial, and published estimates very considerably. An epidemiologic study of 1490 patients who underwent splenectomy in Western Australia over 12 years examined a trauma cohort (n = 628) that was included. After trauma, the incidence and mortality of late OPSI was 0.03 per 100 person year's exposure [6]. However, the incidence of OPSI after splenectomy for trauma is still not known.

Currently, the standard of care for post-splenectomy patients includes immunization with polyvalent pneumococcal vaccine (PPV 23, H. influenza type b conjugate and meningococcal polysaccharide vaccine) within 2 weeks of splenectomy [26]. Despite this established standard the literature reflects a diverse 11 to 75% post-splenectomy immunization rate [23]. Thus, a standardized immunization behavior would further improve the outcome after splenectomy. Initially, one has come to a different conclusion. A paradigm shift in the 90ies hence led to an improved outcome after splenic trauma. During the observation period of this study (1993-2000) there was a fundamental shift to more conservative managed splenic injuries, Table 7. The increasing preservation rate from 51.2% to 39.6% leads to a lower mortality rate from 27.3% to 20.3%. Improved survival rates during this time superposed the immunization behavior and finally led to an improvement oft he total outcome [2].

Despite the known risk of OPSI, there are risk factors associated with the non-operative treatment regimen. Cocanour examined the incidence and type of delayed complications from non-operative management of adult splenic injury. Therefore, 280 patients were admitted with blunt splenic injury. The mean age was 32.2 ± 1.0 years and the mean ISS was 22.8 ± 0.9. Fifty-nine patients (21%) died of multiple injuries within 48 hours and were eliminated from the study. 134 (48%) patients were treated operatively within the first 48 hours after injury and 87 (31%) patients were managed non-operatively. Cocanour et al reviewed the number of PRBC transfused, ICU length of stay, overall length of stay, outcome, and complications occurring more than 48 hours after injury directly attributable to the splenic injury. The study demonstrated

Table 7. Increase of nonoperative management from 1993 to 2005.

Time period	N	ISS	Mortality (%)	Splenectomy (%)
1993-2000	535	40.3	27.3	51.2
2001-2003	641	39.1	22.5	47.4
2004-2005	453	37.0	20.3	39.6

that patients managed non-operatively had a significantly lower ISS ($p<0.5$) than patients treated operatively. Length of stay was significantly decreased in both the number of ICU days as well as total length of stay ($p<0.5$). The number of PRBC transfused was also significantly decreased in patients managed non-operatively ($p<0.5$). In conclusion, a significant number of delayed splenic complications occurred during the non-operative management of splenic injuries and were potentially life-threatening [5].

Furthermore, the recognition of infections and other risks associated with blood transfusion, which may be required with non-operative management, has led to a higher threshold to avoid transfusions and, thus, tolerate lower hematocrits. Luna and Dellinger analyzed the risk of death from post-transfusion hepatitis per PRBC transfused to be 0.14% and death from OPSI at 0.026% of adults who undergo splenectomy and 0.052% of children who undergo splenectomy. Based on these figures, the conditional probability of death in a child who initially undergoes non-operative observation therapy is 0.17%, compared with 0.06% for initial operative therapy. In adults, 0.26% of observed patients die, compared with 0.06% for those operated initially.

In our study we were able to demonstrate the standardized mortality rate for the RISC score was 0.93 % in the group with splenectomy (n = 758) and 0.97 % in the group without splenectomy (n = 872). Our study showed a survival rate of 22.2% in the non-operative cohort, which was lower than in the operative group (24.8%). Similar conclusions are also found in other studies. Our overall results showed no differences in the rate of postoperative infectious complications in patients without splenectomy (18.4%), compared with those who were managed operatively (18.3%).

The study presented could show an AIS spleen score-dependent distribution of the various rates in splenectomy and non-splenectomy patients. At that, non-splenectomy patients with AIS spleen score 2-3 had better sepsis-, OF- and MOF-rates as well as mortality rates. Conversely, these patients did not profit from conservative management when the AIS spleen score was 4-5. In that case, splenectomy patients showed significantly better rates over all sub-analyses studied. Reverse results were obtained by Wiseman and colleagues. They reviewed all trauma patients undergoing splenectomy in a two year period. Though, each splenectomy patient was matched to a unique trauma patient who underwent laparotomy without splenectomy based on age, gender, mechanism of injury, ISS, and presence of colon or other hollow visceral injury. There were 98 splenectomy patients and 98 controls. The splenectomy patients had more overall infectious complications (45% vs. 30%, $p = 0.04$) trended toward more urinary tract infections (12% vs. 5%, $p = 0.12$), and more often had pneumonia (30% vs. 14%, $p = 0.02$). Additionally, more splenectomy patients developed multiple infections (20% vs. 7%, $p = 0.01$). Like us, they found no significant differences in mortality (11% vs. 8%, $p = 0.63$). Recapitulatory, Wiseman et al postulated that splenectomy is associated with an increase in infectious complications after laparotomy for trauma. This increase in infections is not associated with increased mortality [30]. Also Gauer et al., as mentioned before, describe an increased infection rate after performed splenectomy in their youngest study 2008. In this, although prospective study, only 155 patients could be included. No sub-group analysis in dependence of the respective grade of trauma was carried out. Hence, only a very general statement regarding the total collective could be given, not however describe the essential AIS spleen score-dependent differences in the splenic injured – as presented by us. In addition, higher rates of sepsis, OF and MOF can also always be triggered by increased loss of blood. However, we could not assess increased mortality even in average 8.5 units/patient after performed splenectomy due to trauma in comparison to non-splenectomy patients with significantly lower PRBC-substitution (5 units/patient).

In contrast, we were able to show that despite an increased application of PRBC and at the same time high, however identical ISS in both patient collectives the outcome due to splenectomy will only be improved, Table 6. After synopsis of the results, conservative procedure is gold standard, however with high-level injuries (>AIS spleen 4) and continuing blood loss, a conservative procedure may not be forced. In this case, splenectomy should be performed without further delay. As a specific risk for the OPSI-syndrome is not known but presumably low, the splenic preservation still has first priority; a respective immunization, however, has to be demanded.

Conclusion

Non-operative management leads to lower systemic infection rates and mortality in adult patients with moderate blunt splenic injury (Grade 2-3) and should therefore be advocated. Patients with Grade 4 and 5 injury, patients with massive transfusion of PRBC and unstable patients should be managed operatively as soon as possible to prevent further development of hemorrhaging shock.

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