Management of the Most Severely Injured Spleen

A Multicenter Study of the Research Consortium of New England Centers for Trauma (ReCONECT)

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Objective: To determine the rate and predictors of failure of nonoperative management (NOM) in grade IV and V blunt splenic injuries (BSI).

Design: Retrospective case series.


Patients: A total of 388 adult patients with a grade IV or V BSI who were admitted between January 1, 2001, and August 31, 2008.

Main Outcome Measures: Failure of NOM (f-NOM).

Results: A total of 164 patients (42%) were operated on immediately. Of the remaining 224 who were offered a trial of NOM, the treatment failed in 85 patients (38%). At the end, 64% of patients required surgery. Multivariate analysis identified 2 independent predictors of f-NOM: grade V BSI and the presence of a brain injury. The likelihood of f-NOM was 32% if no predictor was present, 56% if 1 was present, and 100% if both were present. The mortality of patients for whom NOM failed was almost 7-fold higher than those with successful NOM (4.7% vs 0.7%; P = .07).

Conclusions: Nearly two-thirds of patients with grade IV or V BSI require surgery. A grade V BSI and brain injury predict failure of NOM. This data must be taken into account when generalizations are made about the overall high success rates of NOM, which do not represent severe BSI.

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The management patterns of blunt splenic injuries (BSI) have shifted from routine splenectomy to nonoperative management (NOM) over the last 3 decades.1,2 Although low-grade injuries are successfully managed without surgery, NOM of high-grade BSI is associated with frequent failures.3-8 In one of the largest multicenter studies, the failure of NOM was 4.8% for grade I, 9.5% for grade II, 19.6% for grade III, 33.3% for grade IV, and 75% for grade V BSI.9 Therefore, the effectiveness of NOM for grade IV and V injuries is under scrutiny. Most studies have a prohibitively low number of such injuries to draw valid conclusions.

The ReCONECT (Research Consortium of New England Centers for Trauma) initiative focuses on using high numbers of patients to evaluate research topics that are difficult to address by any single institution. Our hypothesis for this study is that most grade IV and V BSI require surgery and that certain risk factors increase the likelihood of receiving an operation. The objective of the study is to determine the rate and risk factors of failure of NOM in patients with BSI.

Methods

Patients

Adult patients with a grade IV or V BSI who were admitted from January 1, 2001, to August 31, 2008, in 14 New England trauma centers were included retrospectively. Grading was performed individually by each center based on computed tomographic (CT) findings and according to the American Association for the Surgery of Trauma Organ Injury Scale (Table 1).10

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Table 1. Grading of Splenic Injury According to the American Association for the Surgery of Trauma Organ Injury Scale10

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td>Subcapsular hematoma, &lt;10% of surface area; laceration, &lt;1 cm parenchymal depth</td>
</tr>
<tr>
<td>II</td>
<td>Subcapsular hematoma, 10%-50% of surface area, &lt;5 cm in diameter; laceration, 1-3 cm in depth</td>
</tr>
<tr>
<td>III</td>
<td>Subcapsular hematoma, &gt;50% of surface area or expanding; laceration, &gt;5-cm depth or expanding; intraparenchymal hematoma, &gt;3 cm or expanding</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration involving segmental or hilar vessels producing major devascularization</td>
</tr>
<tr>
<td>V</td>
<td>Completely shattered spleen; hilar injury that devascularizes the entire spleen</td>
</tr>
</tbody>
</table>

aAdvance 1 grade for multiple injuries up to grade III.

All centers were verified by the American College of Surgeons Committee on Trauma as level I (11 centers) or II (3 centers) trauma centers. Patients who received a resuscitative thoracotomy in the emergency department were excluded, as none eventually survived.

**DEFINITIONS**

Patients were categorized as receiving NOM or an immediate operation (IO). Nonoperative management was defined by either a clear note in the medical record committing the patient to NOM or by the fact that no operation was performed within 3 hours of diagnosis of BSI. The 3-hour limit was arbitrary and based on a consensus among the centers that it would be very unlikely to decide to perform an operation for a high-grade splenic injury and delay it for more than 3 hours. However, it is plausible that there were patients who were offered NOM initially but for whom it failed in fewer than 3 hours. These patients may have been recorded as having received IO. Failure of NOM was defined as the need for surgery after a trial of NOM.

**DATA AND OUTCOMES**

We collected data on demographics, mechanism of blunt trauma (motor vehicle–related crash, fall, or assault), severity of injury according to the Injury Severity Score, associated injuries, grade of splenic injury (IV or V), presence of free abdominal blood on CT (around the spleen only or diffuse), type of management (NOM or IO), failure of NOM (f-NOM), morbidity, mortality, and length of hospital stay. The outcome measure was f-NOM.

**STATISTICAL ANALYSIS**

Patients who received NOM and IO were compared. Additionally, patients with f-NOM were compared with patients who had successful NOM (s-NOM). Continuous variables were dichotomized across clinically meaningful values. Age was dichotomized at 55 years; systolic blood pressure, 100 mm Hg; heart rate, 100 beats per minute; Injury Severity Score, 25; and hematocrit level, 30%. Continuous variables (reported as mean [standard deviation] unless otherwise specified) were compared using the t test and categorical variables (reported as absolute values and proportions) by the χ² or Wilcoxon rank sum tests. Stepwise logistic regression was performed to identify independent predictors of f-NOM. Odds ratios and 95% confidence intervals were calculated for each predictor. The predictive ability of different combinations of independent predictors of f-NOM was examined. P ≤.05 indicated statistical significance. The study was approved by the institutional review boards of all participating hospitals.

**RESULTS**

Of 388 patients with grade IV or V BSI admitted during the study period in the 14 ReCONECT hospitals, 164 (42%) were operated on immediately and 224 (58%) were offered NOM. The mean (SD) age of the population was 38 (17) years (median, 36 years; range, 16-98 years) and Injury Severity Score, 31 (12) (median, 29; range, 8-66). Sixty-nine percent were men, 19% had grade V injury, 33.5% had other intra-abdominal organ injuries, 13% had a brain injury, and 20% had long bone or pelvic fractures. The average hospital stay was 13 (18) days (median, 7 days; range, 1-205 days). Thirty-three patients (8.5%) died.

**NOM vs IO**

All examined variables except for age, sex, the presence of free blood, and contrast extravasation on CT were significantly different between patients who received NOM and IO (Table 2). As expected, patients who received IO had higher morbidity, mortality, and length of hospital stay.

**s-NOM vs f-NOM**

Of 224 patients who were initially offered NOM, it failed in 85 (38%) within 2 (3.5) days of admission (median, 1 day; range, 0-18 days) and required surgery. In 66% of patients, the failure occurred within 24 hours; in 18%, between 24 and 48 hours; and in 16%, after 48 hours up to 18 days after admission. The NOM failure rate was 34.5% among patients with grade IV and 60% among patients with grade V injury. Compared with s-NOM, patients with f-NOM had higher rates of brain injury, grade V BSI, and contrast extravasation on CT (Table 3). They had higher morbidity, longer hospital stay, and a trend toward higher mortality.

The multivariate analysis identified 2 independent predictors of failure of NOM: a grade V BSI and the presence of brain injury (Table 4). The likelihood of f-NOM was 32% if none of the 2 predictors were present, 56% if 1 was present, and 100% if both were present.

In an additional multivariate analysis, we considered a P value of .1 significant to allow inclusion of more variables. This analysis identified 2 additional independent predictors of NOM failure: male sex and contrast extravasation on CT (Table 5). The likelihood of NOM failure was 22% if no predictor was present, 32% if 1 was present, 40% if 2 were present, and 78% if 3 were present.
There were no patients with all 4 predictors present to estimate a likelihood of NOM.

**PATIENTS WHO RECEIVED SURGERY**

Overall, 64% of patients (249 of 388) received surgery, 60% with grade IV and 83.5% with grade V BSI. In all but 2 patients who had splenorrhaphy, a splenectomy was performed.

To examine if patients with f-NOM should have been identified earlier as candidates for immediate surgery, we compared patients with f-NOM and IO. If the 2 groups were similar, we could hypothesize that patients with f-NOM were erroneously offered NOM at the first place. However, the two populations had significant differences in age, Injury Severity Score, blood pressure, heart rate, and hematocrit on arrival, as well as presence of other abdominal and extra-abdominal injuries and grade of splenic injury (data not shown).

**COMMENT**

This multicenter initiative of 14 New England trauma centers included the largest population with grade IV and V BSI to date. The literature of NOM for BSI has increased during the last 2 decades, and (possibly subject to publication bias) the message conveyed has become overly optimistic. As studies reported NOM success rates ranging from 80% to 100%, the fact that only a few severely injured spleens were included was often overlooked. In most studies, high-grade injuries were operated on immediately and excluded from the analysis of NOM. This may have conveyed the false impression that all grades of BSI respond favorably to NOM.

Whereas there is little doubt that NOM is highly successful in grade I, II, and possibly III injuries, the data on higher grades is uncertain. The Eastern Association for the Surgery of Trauma has described a large number of patients with BSI from 27 trauma centers including 194 patients with grade IV and 78 with grade V injuries. Although more than half of the patients were ult-
This new analysis offered contrast extravasation (\textit{P} = .07) as additional predictors. Even if they do not meet the traditional criteria for statistical significance, these variables should be taken into consideration in the treatment of patients with BSI.

This multicenter study is subject to limitations related to its retrospective design and the lack of a common NOM policy in the participating institutions. Also, there was no central authority to grade the injuries, which was done separately in each institution. The reliance on CT grading to predict NOM failure has been debated by some authors.\textsuperscript{13} A number of other factors that have been commonly reported as predictors of NOM failure including age greater than 55 years, spleen pathology, multiple abdominal injuries, number of blood transfusions, time of in-house observation, and quantity of free blood, among many others, were not found to be statistically significant in our study.\textsuperscript{3,5,10,12} Splenic artery embolization was used in only a handful of cases and therefore not reported. Its liberal use has resulted in high rates of NOM success in certain centers,\textsuperscript{16-18} whereas others have not realized similar benefits.\textsuperscript{15} Data on ultrasonographic examinations and diagnostic peritoneal lavage were not collected in our database. Such information has been included in management algorithms offered by consensus groups.\textsuperscript{20} Although we could not examine causality between the failure of NOM and mortality, the nearly 7-fold increase in mortality of patients with I-NOM (4.7%) compared with s-NOM (0.7%) was alarming even if it did not achieve statistical significance (\textit{P} = .07). It is possible that, on certain occasions, persistent attempts to save a severely injured spleen may lead to loss of life. It, of course, needs to be noted that patients with I-NOM had a higher rate of brain injury, which may be a reason for the higher mortality rate in this group.

In summary, this multicenter initiative confirms that only a minority of grade IV and V BSI can be managed without surgery and that the rate of NOM failure is high. Although this study was not designed to evaluate the type and timing of interventions, it is recommended that NOM is offered cautiously in these patients and only if close monitoring and rapid surgical response is available.

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The multivariate analysis identified 2 such independent predictors: a grade V BSI and the presence of a brain injury.

Because we realized that some variables closely approached the arbitrary .05 level of statistical significance, we relaxed our \textit{P} value to .1 to consider other potential factors that predict NOM. Besides grade V BSI and brain injury, which remained statistically significant predictors of NOM at \textit{P} values of .01 and .05, respectively, this new analysis offered contrast extravasation (\textit{P} = .07) and male sex (\textit{P} = .09) as additional predictors. Even if they do not meet the traditional criteria for statistical significance, these variables should be taken into consideration in the treatment of patients with BSI.

\begin{table}
\centering
\caption{Table 4. Independent Predictors of Failure of Nonoperative Management}
\begin{tabular}{|l|l|l|}
\hline
Predictor & OR (95\% CI) & \textit{P} Value \\
\hline
Spleen injury grade V & 3.01 (1.36-6.67) & .007 \\
Brain injury & 2.82 (1.14-7.01) & .03 \\
\hline
\end{tabular}
\end{table}

\begin{table}
\centering
\caption{Table 5. Independent Predictors of Failure of Nonoperative Management When Level of Significance Was \textit{P} < .1 Instead of \textit{P} < .05}
\begin{tabular}{|l|l|l|}
\hline
Predictor & OR (95\% CI) & \textit{P} Value \\
\hline
Spleen injury grade V & 2.84 (1.26-6.40) & .01 \\
Brain injury & 2.50 (0.99-6.28) & .05 \\
Contrast extravasation on CT & 1.71 (0.96-3.01) & .07 \\
Male sex & 1.74 (0.92-3.28) & .09 \\
\hline
\end{tabular}
\end{table}
Preservation of the Most Severely Injured Spleen: Is There Anything New?

The NOM failure rate in this study was 34.5% for patients with grade IV and 60% for grade V injury, comparing favorably with the failure rate of 33.3% for grade IV and 75% for grade V reported in the Eastern Association for the Surgery of Trauma (EAST) multi-institutional study¹ in 2000.

In this study grade V splenic injury and brain injury were independent predictors of failure of NOM, and contrast extravasation and brain injury were associated with increased length of stay, morbidity, and trend toward increased mortality.

Recent literature²,³ has suggested that vascular injuries of the spleen (e.g., active splenic bleeding, pseudoaneurysm formation, posttraumatic arteriovenous fistula seen on contrast enhanced CT) are associated with increased likelihood of failed NOM, and that CT-based grading algorithms that incorporate vascular injuries are more discriminating in identifying high-grade splenic in-