Delayed hemorrhagic complications in the nonoperative management of blunt splenic trauma: Early screening leads to a decrease in failure rate

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BACKGROUND: Delayed splenic rupture is the Achilles' heel of nonoperative management (NOM) for blunt splenic injury (BSI). Early computed tomographic (CT) scanning for features suggesting high risk of nonoperative failure, splenic pseudoaneurysms (SPAs), and arterial extravasation (AE), in concert with the appropriate use of splenic arterial embolization (SAE) is a viable method to reduce rates of failure of NOM. We report our 12-ear experience with a protocol for mandatory repeat CT evaluation at 48 hours and selective SAE.

METHODS: A retrospective cohort analysis was performed on all consecutive adult trauma patients with BSI between 1995 and 2012. We evaluated an early/control (1995–1999) and a present/intervention (2000–2012) cohort in which SAE became available and 48-hour CT scans were implemented.

RESULTS: The study included 773 patients (157 early vs. 616 present) with BSI. The proportion of patients managed nonoperatively (53% vs. 77%, $p < 0.01$) and overall splenic salvage rate (46% vs. 77%, $p < 0.01$) were improved in the present cohort. Among patients selected for NOM, there was a significant improvement in the failure rate of NOM (12% vs. 0.6%, $p < 0.01$) as well as in the length of hospital stay (8 days vs. 6 days, $p < 0.01$). Delayed development of SPA and/or AE was detected in 6% of BSI in the present cohort and was distributed among all grades of injury.

CONCLUSION: The delayed development of SPA and AE is not an entirely rare event following BSI. Reevaluation with CT at 48 hours following admission and the use of SAE significantly decrease the failure rate of NOM. (*J Trauma Acute Care Surg*. 2014;76: 1349–1353. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Therapeutic study, level III.

KEY WORDS: Trauma; spleen; embolization.

Nonoperative management (NOM) of blunt splenic injury (BSI) is the standard of care for selected hemodynamically stable patients.[1–10] An impressive amount of data has been reported on this subject over the preceding decade. The Eastern Association for the Surgery of Trauma recently updated its guidelines for NOM of BSI based on evidence from more than 175 peer-reviewed publications.[11] Despite this, several questions remain unanswered, and a single, universal treatment protocol has not been accepted. Of particular interest is the role of repeat computed tomographic (CT) imaging and the optimal use of splenic arterial embolization (SAE).

SAE has proven an effective adjunct in the NOM of BSI.[7,12–15] SAE may be used in the initial phase of management when arterial extravasation (AE) is seen on initial CT scan or to treat delayed splenic pseudoaneurysm (SPA) formation diagnosed on repeat imaging.[6,16–18] Although the natural history of SPA is not entirely known, a growing body of evidence supports the belief that they are responsible for delayed splenic rupture and the majority of failures of NOM for BSI.[19–21]

During the last 12 years, our institution has mandated that all patients with any grade of BSI be screened with repeat CT at 48 hours. All high-risk lesions (SPA and AE) detected on repeat imaging are aggressively managed with either selective or proximal SAE. The purpose of this study was to evaluate and compare the present management algorithm for BSI (2000–2012, Fig. 2) against a historical control cohort (1995–1999, Fig. 1). We hypothesized that the new algorithm for BSI would result in a decreased failure rate in the NOM of BSI.

PATIENTS AND METHODS

A retrospective cohort analysis was performed on all consecutive adult (age > 16 years) trauma patients with BSI admitted to our Level 1 trauma center from January 1995 to December 2012. Patients who arrived without vital signs or who expired in the trauma bay were excluded. All data were gathered from our prospectively maintained hospital trauma

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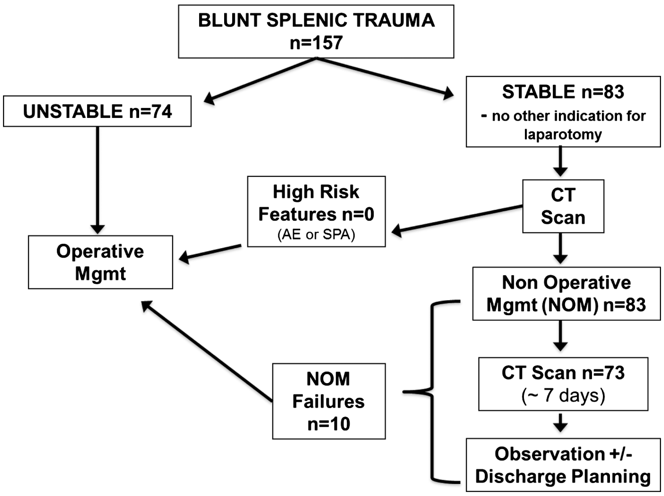

Figure 1. Early cohort algorithm for the management of blunt splenic trauma.

registry. Data collected from the registry included demographic information, Injury Severity Score (ISS), splenic injury grade, laboratory values, use of SAE, CT scan findings, comorbidities, and complications. The health sciences research ethics board at Western University, London, Ontario, Canada, reviewed the study and provided ethics approval for the study.

Before 2000, follow-up CT scans were performed on selected BSI patients at 7 days, and SAE was not available (Fig. 1). In 2000, the algorithm was updated, owing to concerns that SPA could lead to rupture as early as 48 hours, such that follow-up CT scans were performed within 48 hours on all BSI patients and any AE or SPAs were managed with SAE (Fig. 2). We compared the early and present cohorts with failure rate of NOM as our primary outcome. Failure of NOM was defined as operative splenectomy that was performed following patient enrollment into the NOM pathway. Secondary outcomes included detection rate of delayed SPAs and AE, hospital length of stay (LOS), transfusion requirements, and mortality.

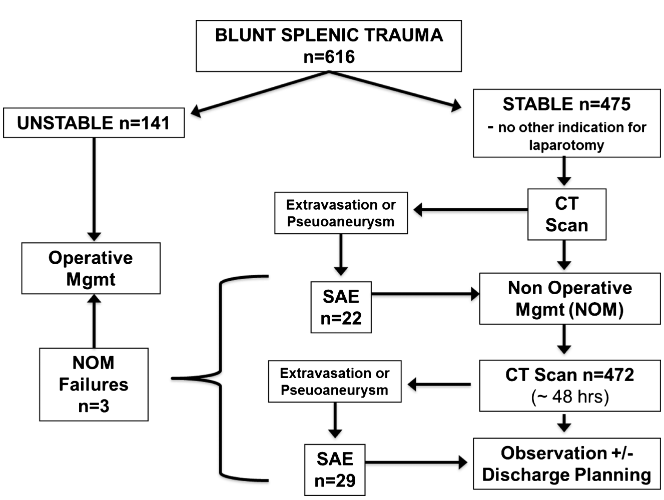

Figure 2. Present cohort algorithm for the management of blunt splenic trauma.

TABLE 1. Baseline Characteristics of Patients Selected for NOM in the Early and Present Cohorts

Characteristics	Early (n = 83)	Present (n = 475)	*P*
Age, median (IQR)	31 (32)	32 (28)	0.73
ISS, median (IQR)	29 (18)	26 (15)	0.15
Spleen grade, median (IQR)	1 (3)	2 (2)	0.09
Initial heart rate, median (IQR)	100 (27)	94 (28)	0.20

AE was defined as free flow of contrast from the spleen into the peritoneal cavity, and SPA was defined as a well-circumscribed intrasplenic focus of contrast enhancement.[18,22]

Abdominal CT scan radiology reports were reviewed, and splenic injuries were graded according to the American Association for the Surgery of Trauma Organ Injury Scale (OIS).[23] In those patients without radiologist reported grades, two authors (W.R.L. and N.P.) independently reviewed the CT scan and generated splenic grades according to the American Association for the Surgery of Trauma splenic OIS. Authors were blinded to patient factors and outcomes when assigning splenic injury grade based on CT imaging. Operative notes and pathology reports were reviewed to obtain the appropriate splenic injury grades for any patients managed operatively.

All data were screened for normality, and skewed data points were presented as medians with interquartile range (IQR). Categorical outcomes were compared using Pearson's χ^2 and Fisher's exact tests, and continuous outcomes were compared using Mann-Whitney U-test or Kruskal-Wallis test. Results were considered statistically significantly with a $p < 0.05$. All analyses were performed using IBM SPSS Statistics version 21 (IBM Corporation, Armonk, NY).

RESULTS

Seven hundred seventy-three patients with BSI were identified during the study period. The early cohort had 157 patients, while 616 patients were managed in the present cohort. In each cohort, a certain proportion of patients were taken directly to the operating room for immediate laparotomy owing to hemodynamic instability or signs of peritonitis. The remaining subset of patients was given an initial trial of NOM. Table 1 compares the baseline characteristics of patients who were initially treated with NOM. In the present cohort, a significantly higher portion of the total population of BSI patients was selected for NOM as compared with the early cohort (77% vs. 53%, $p < 0.01$). No significant difference was observed in demographics, injury severity, or initial heart rate between the two cohorts. The distribution of splenic injury grade was not significantly different between the cohorts.

Outcomes for patients who underwent initial NOM are presented in Table 2. A significant improvement in the failure rate of NOM was observed in the present cohort as compared with the early cohort (0.6% vs. 12%, $p < 0.01$). A reduction in LOS was also seen in the present cohort as compared with the early cohort (6 days vs. 8 days, $p < 0.001$). No difference in transfusion requirement or mortality was observed between the present and early cohorts. All patient deaths in the study were reviewed in duplicate by two authors (W.R.L. and T.J.L.). The

TABLE 2. Outcomes of Patients Selected for NOM in the Early and Present Cohorts

Characteristics	Early Cohort (n = 83)	Present Cohort (n = 475)	*p*
Proportion of all BSI patients, %	53	77	<0.01
Failure of NOM, n (%)	10 (12)	3 (0.6)	<0.01
LOS, median (IQR)	8 (12)	6 (6)	<0.01
Required transfusion, n (%)	30 (39)	152 (32)	0.29
Total units of packed red blood cells, mean (SD)	0 (2)	0 (2)	0.45
Mortality, n (%)	2 (2.4)	24 (5.0)	0.36

cause-of-death analysis among NOM patients in the present cohort revealed that a considerable majority (16 of 24 or 67%) died of traumatic brain injury and subsequent withdrawal of life support. No deaths were directly attributable to delayed splenic rupture or splenic complications of any kind.

Of the 475 patients in the present cohort selected for NOM, approximately 5% were found to have high-risk lesions on their initial CT scan, while an additional 6% went on to have high-risk lesions (SPA and/or AE) on follow-up CT imaging. Delayed development of SPA and/or AE was increasingly likely with higher grade of splenic trauma; however, more than 20% of delayed lesions were seen in Grades 1 and 2 (Fig. 3).

Among patients undergoing SAE, a total of 19 patients (37%) received proximal embolizations, while the remaining 32 patients (63%) received distal selective embolizations. There were a total of four complications associated with SAE including one groin hematoma, one episode of severe postembolization abdominal pain, and one iatrogenic splenic artery branch dissection treated by proximal embolization. The fourth patient had a delayed bleed requiring operative splenectomy 11 days after undergoing SAE based on the initial CT.

DISCUSSION

During the last decade, many institutions have incorporated a more aggressive approach to the NOM of BSI.[19,24,25] However, a standard protocol for the NOM of BSI has not yet been universally accepted. Considerable variation still exists in the management algorithms not only between institutions but also between trauma surgeons within the same institution.[24] The appropriateness and timing of interval follow-up CT and the effect of SAE on the rates of NOM failure remain two important points of contention.

Before 2000, the BSI protocol at our center suggested a follow-up CT scan at approximately Day 7 following BSI at the discretion of the treating team. In response to a sentinel delayed splenic rupture event, a review of our local data on NOM was conducted. The pathophysiologic process leading to splenic rebleeding seemed to be occurring before the 7-day follow-up study, and as such, we altered our algorithm to include a follow-up CT scan at 48 hours rather than 7 days. We hypothesized that a 48-hour CT scan would reliably identify the latent SPAs, permit earlier SAE, and reduce failure rates of NOM.

The pioneering work on this topic and indeed the data on which our present NOM algorithm was modeled were contributed by Fabian et al.[19,20] In a series of studies spanning almost 20 years, they have demonstrated the presence of high-risk imaging features on CT to be a predictor of failure of NOM for BSI[19] and that follow-up CT scans at 24 hours to 48 hours could be combined with SAE to produce an impressive reduction in the rate of NOM failure to as low as 3%.[20] Despite this evidence, the routine use of follow-up CT imaging has not been universally embraced. In fact, a recent Eastern Association for the Surgery of Trauma survey suggests that only 14.5% of surgeons performed routine follow-up CT scans for BSI patients.[24]

We have demonstrated a significant increase in the proportion of BSI patients being selected for NOM in the present cohort (77% vs. 53%). Factors responsible for this change may have included increasing surgeon comfort with NOM and increasing awareness of the value of SAE. The median grade of splenic injury among patients selected for NOM showed a trend toward increased injury severity in the present cohort (median splenic injury grade of 2 vs. 1, $p = 0.09$). Despite the selection of a higher proportion of potentially more severely injured spleens for NOM, our study demonstrated a significant improvement in the overall rate of failure of NOM over historical control from 12% to 0.6%. In addition to improved splenic salvage, the present cohort also demonstrated a shorter length of hospital stay (6 vs. 8 days). No differences in the requirement for blood transfusions, amount of blood transfused, or overall NOM mortality were seen.

Although these improvements over time are certainly multifactorial, the role of SAE in improving NOM failure rates and decreasing lengths of stay merits further discussion. In total, 51 patients (11%) selected for NOM in the present cohort had SPA and/or AE and required SAE. SAE was seen to be both safe and effective. Only one patient went on to fail SAE and require splenectomy, and there were only three other minor complications. Interestingly, when one compares the proportion of patients selected for NOM who failed in the early cohort (10 of 83, 12%) it is nearly identical to the proportion of patients selected for NOM who went on to be treated with SAE (51 of 473, 11%) in the present cohort.

The concept of delayed splenic rupture is central to the rationale of interval follow-up CT scanning in BSI. To

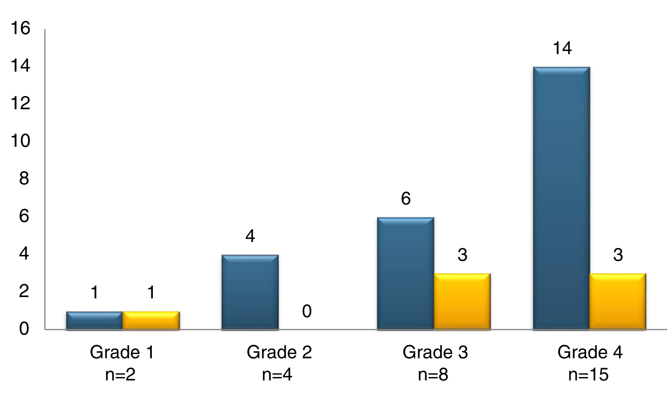

Figure 3. Distribution of delayed findings (SPA and AE) by splenic grade (n = 29).

rationalize the resource use and contrast/radiation risks associated with follow-up CT imaging, a careful consideration of available data is warranted.

Several studies have helped shed light on the rate of occurrence of latent SPA and on the overall rate of delayed splenic rupture through a variety of methodologies. Savage et al.[26] have demonstrated that the probability of development of delayed SPA on interval CT is between 3% and 5%. One of the largest series reported among centers who do not routinely repeat CT imaging demonstrated the need for late use of SAE in 6% of the patients,[27] likely serving as a surrogate for the delayed development of SPA/AE. Our rate of latent or delayed imaging findings of 6% is in keeping with both of these reports.

When considering a population of outpatients receiving CT imaging during clinic follow-up, a 10% rate of progression/worsening of splenic injury has been demonstrated.[26] Population-based studies suggest that between 1.5% and 1.8% of similar discharged outpatients may re-present to the hospital with delayed splenic rupture requiring splenectomy.[28,29]

Given the low but consistent and reproducible rates of latent development of SPA, approximately 6%, it is unlikely that global mortality or morbidity figures would be impacted by interventions targeted at this subset of BSI patients. However, the morbidity and mortality associated with delayed splenic rupture are considerable for the 1 in 20 patients who experience this complication. In light of the present data, which suggest the ability to intervene early and reduce rates of NOM failure, we continue to support a liberal approach to interval reimaging for BSI.

Efforts to better select the patients who will most benefit from reimaging are an important target for future research. Grade and age alone have been used to determine the need for follow-up CT with the most recent protocol published by the University of Tennessee/Memphis group indicating that they withhold follow-up CT imaging on Grade 1 injuries in patients younger than 55 years.[21] Although it is clear that latent SPA and AE develop predominantly in higher-grade injuries, more than 20% of such lesions developed in Grade 1 and 2 injuries in our series (Fig. 3). It is conceivable that a prediction tool based on other factors in addition to age and grade (such as injury mechanism, presence of subcapsular hematoma, etc.) could be developed to better select patients for repeat imaging. However, given the small but real risk of delayed rupture even in low-grade injuries, we continue to reimage all patients with BSI while considering future directions of research to continually update this practice.

One limitation of the present study, which must be addressed, is the inevitable evolution of trauma care throughout the 17-year study period. Although this study focused on the introduction of SAE and repeat CT imaging, there were likely other improvements in trauma care (ventilation strategies, damage-control techniques, etc.) that may have contributed to the improved success rate in the present cohort. However, the key findings of this study, including the improved rate of successful NOM for BSI, are unlikely to have been influenced principally by the time course of this study.

In summary, the present study represents the lowest rate of failure for NOM of BSI reported in the literature to date. Our current algorithm markedly improved splenic salvage rates and decreased hospital LOS. Repeat CT within 48 hours of admission and prompt endovascular intervention when appropriate are considered to be key components of this highly successful protocol.

AUTHORSHIP

W.R.L., T.J.L., D.O., S.K., N.G.P., and D.K.G. designed this study. W.R.L., T.J.L., T.S., T.C.-S., S.K., N.G.P., and D.K.G. contributed to data collection. W.R.L., T.J.L., T.C.-S., N.G.P., and D.K.G. performed data analysis. W.R.L., T.J.L., D.O., B.M., N.G.P., and D.K.G. wrote the manuscript. W.R.L., T.J.L., B.M., T.C.-S., N.G.P., and D.K.G. contributed to critical revision.

DISCLOSURE

The authors declare no conflicts of interest.

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