Blunt Aortic Injury with Concomitant Intra-abdominal Solid Organ Injury: Treatment Priorities Revisited

John M. Santaniello, MD, Preston R. Miller, MD, Martin A. Croce, MD, Laura Bruce, MD, Tiffany K. Bee, MD, Ajai K. Malhotra, MD, and Timothy C. Fabian, MD

**Background:** Patients with blunt aortic injury (BAI) often have concomitant liver or spleen (L/S) injuries. With increasing use of cardiopulmonary bypass with heparinization in repair of BAI, many advocate operative management of the L/S injury before aortic repair to eliminate risk of hemorrhage. We evaluated the safety of nonoperative management (NOM) of blunt L/S injuries in patients undergoing acute BAI repair with bypass.

**Methods:** All patients admitted over a 6-year period with BAI were identified from the registry of our Level I trauma center. Patients with isolated L/S injuries without BAI admitted over the same period served as controls. Groups were compared with regard to demographics, injury characteristics, hospital course, and mortality.

**Results:** Eighty-four patients were diagnosed with BAI from 1994 to 2000; 28 (33%) also had blunt abdominal trauma. Three patients with severe brain injury did not undergo BAI repair, and five required laparotomy before BAI repair for other intra-abdominal injuries (two for hemodynamic instability with splenic injury, and three for concomitant bowel injury). Therefore, 20 of 28 (71.4%) BAI patients with grade I or II L/S injury (Aorta L/S group) underwent planned NOM. All BAI were repaired using partial bypass with full heparinization. These 20 patients are compared with 894 patients with grade I or II L/S injuries with no BAI (L/S group) over the same time period. There was no difference in the nonoperative failure rate of the Aorta L/S group versus the L/S group (0% vs. 1.7%). Both groups had similar complication rates. The Aorta L/S group was also compared with 56 BAI's without solid organ injury (Aorta group). Although the Aorta L/S group was more severely injured than the Aorta group (Injury Severity Score of 35.3 vs. 26.8, \( p < 0.0001 \)), transfusion rates (5.7 U of packed red blood cells vs. 8.0 U of packed red blood cells, \( p = NS \)), hospital days (17.9 vs. 19.1, \( p = NS \)) and mortality (10% vs. 9%, \( p = NS \)) were similar.

**Conclusion:** NOM of patients with grade I or II L/S injury who undergo systemic anticoagulation with heparin for repair of BAI is safe and associated with transfusion rates similar to BAI alone. Patients with low-grade liver or spleen injuries do not require laparotomy before BAI repair using partial bypass.

**Key Words:** Blunt aortic injury, Liver and spleen, Nonoperative management, Heparin.

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(CT) scans (Siemens Somatom Plus 4, Erlangen, Germany). Suggestion of aortic injury on CT scan prompted mandatory thoracic aortography. Patients with suspected aortic injury had their blood pressure and heart rate controlled with the use of pharmacologic agents (β-blockade and sodium nitroprusside when necessary) to keep systolic blood pressure at approximately 100 mm Hg and heart rate of < 100 beats/min. All BAI was repaired using partial bypass with full heparinization (400 U/kg). Aortic repair was carried out shortly after admission, with the exception of patients with severe brain injury, in whom early operative intervention may be dangerous with systemic anticoagulation.

### Solid Organ Injury Management

All hemodynamically normal patients with a liver or spleen injury had their injuries diagnosed by CT scan and underwent serial physical examinations and, in some cases, follow-up ultrasound for ongoing evaluation of hemoperitoneum. Serial hematocrits were also obtained on these patients. All liver and spleen injuries were graded according to the American Association for the Surgery of Trauma organ injury scale by an attending radiologist and trauma attending. These patients all underwent follow-up CT scanning within 48 hours to evaluate their solid organ injury.

The Aorta L/S group was compared with the control group (L/S group) with respect to outcome of NOM, age, ISS, and hospital days. To determine whether NOM added to the morbidity of the Aorta L/S group, they were also compared with patients with BAI and no solid organ injuries (Aorta group).

Statistical analysis was performed using StatView 5.0 (SAS Institute, Inc., Cary, NC). Dichotomous variables were compared using χ² or Fisher’s exact test where appropriate, and continuous variables were compared using Student’s t-test. A value of p < 0.05 was considered significant.

### RESULTS

From June 1994 to January 2000, 84 patients were admitted with BAI. Motor vehicle crash was the mechanism of injury in 78 (93%), with pedestrians struck by vehicles representing 7% (n = 6). There were 56 patients without associated intra-abdominal injury, whereas 28 patients (33%) had concomitant liver and/or spleen injury. Three of these patients did not undergo acute BAI repair because of severe brain injury. Five were excluded from nonoperative management of their L/S injuries: three for enteric injuries (two small bowel, one colon), and two for hemorrhagic instability because of splenic injuries (both grade IV). Therefore, 20 of 28 (71%) patients with solid organ injury (13 liver, 6 spleen, 1 both) constituted the study cohort (Aorta L/S group). All liver or spleen injuries in this group were either grade I or II and the distribution of these injuries is shown in Table 1. These patients underwent planned nonoperative management of their solid organ injuries without delay in aortic repair.

### Table 1 Injury Distribution in the Aorta L/S Group

<table>
<thead>
<tr>
<th>Organ</th>
<th>Grade I</th>
<th>Grade II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Spleen</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

During the same time period, 603 patients with grade I and II hepatic injuries (313 grade I and 290 grade II) and 291 patients with grade I and II splenic injuries (144 grade I and 147 grade II) were admitted, and these 894 patients served as controls (L/S group). The group characteristics as well as outcomes are shown in Table 2.

There were no outcome differences between groups relative to resource use (length of stay) or failure of nonoperative solid organ injury management. Thus, the use of systemic anticoagulation for aortic repair appears safe in this population.

To determine whether nonoperative solid organ injury management in patients with BAI impacted BAI repair, patients with aortic injury without solid organ injury (Aorta group) were compared with those with both (Aorta L/S group). These data are shown in Table 3. Although the ISS for the Aorta L/S group was predictably higher, transfusion requirements were similar to that for BAI alone. NOM of solid organ injury in BAI patients also did not appear to increase resource use or increase mortality. The mean time to operation for aortic repair was 1.52 days for the Aorta L/S group versus 1.55 days for the Aorta group (p = NS). Thus, NOM of solid organ injury in patients with associated BAI did not affect outcomes relative to operative repair of BAI.

Overall complication rates in the Aorta L/S group and the Aorta group were similar (45% vs. 32%, p = NS), and postoperative paraplegia occurred in one (5%) Aorta L/S
Table 4 Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Aorta L/S (%)</th>
<th>Aorta (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Death</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>5*</td>
<td>2</td>
</tr>
<tr>
<td>Stroke</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Bilateral LE gangrene</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Splenic abscess</td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Iatrogenic femoral vessel injury</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>DVT</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MOF</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

LE, lower extremity; DVT, deep venous thrombosis; MOF, multiple organ failure.
* Excludes one patient detected preoperatively.

DISCUSSION

BAI with accompanying liver or splenic injury continues to confound clinicians for many reasons, with the dilemma of how and when to treat the intra-abdominal injuries among the most controversial. Autopsy studies by Parmley et al. describe a 90% mortality for BAI within 24 hours of admission if left untreated. The need for emergent repair of the aorta generally left little room for debate on the priorities of treatment when no other injury was present. With the evolution of better prehospital care, and improved prehospital survival, an increasing number of these patients reach the hospital alive. Many have other associated injuries that need to be addressed. This number ranges from 50% to 90% according to some studies. With the introduction of β-blockade to reduce aortic wall stress (dP/dt), it has been shown that aortic repair can be safely delayed, with minimal risk of aortic rupture.

Before the use of CT scanning to evaluate blunt abdominal trauma, patients with suspected abdominal injury were either taken directly to the operating room or underwent diagnostic peritoneal lavage. If diagnostic peritoneal lavage was positive, patients would go directly to the operating room for laparotomy, with removal of the spleen if it was injured, or direct repair of the liver for bleeding, followed by aortography (if this was not performed before the laparotomy) and then subsequent aortic repair.

With the recent shift in management strategy of blunt liver and spleen injuries to NOM, concern with the risk of hemorrhage from the injured solid organs during aortic repair has escalated. This is particularly true when aortic repair involves bypass with the use of systemic anticoagulation or the use of heparin-bonded conduits. Many clinicians have approached this problem in one of three ways: first, delaying repair of the aorta until the injured intra-abdominal organ has healed, maintaining patients on β-blockade and antihypertensives; second, performing laparotomy with removal or repair of the injured solid organ with subsequent repair of the aorta at the same operation; or third, using the “clamp-and-sew” method for aortic repair, which obviates the need for heparin. Although delaying aortic repair has been safe in most cases, this has been shown to lead to longer hospitalization and increased costs. Also, despite the stability and low risk of rupture of low-grade liver and spleen injuries after 1 week, delayed hemorrhage has been noted to occur well beyond this time.

With the recent shift in management of hemodynamically normal blunt liver and spleen patients to NOM, the need for laparotomy to “take the spleen (or liver) out of the equation” needs to be questioned. With the morbidity of elective laparotomy exceeding 15%, the unnecessary laparotomy in the trauma patient with multiple injuries exceeds this number. Also, if splenectomy is performed, the patient takes on the additional lifetime risk of post-splenectomy sepsis syndrome. If these solid organ injuries could be managed safely nonoperatively in conjunction with acute repair of BAI, the reduction in morbidity from unnecessary operation alone would be invaluable.

Although partial bypass with full heparinization has been used in patients with BAI and solid organ injuries, reports are few and only case studies exist. However, these studies suggest no increase in the rate of NOM failure for solid organ injury. This is in contrast to a 1994 meta-analysis that showed a higher mortality when heparin was used. The authors of this study recommended using partial bypass without heparin during aortic repair. The issue of the safety of systemically anticoagulating the trauma victim with multiple injuries, especially with spleen or liver injury, has not been resolved. This study has shown that low-grade liver and spleen injuries can be anticoagulated acutely, with little or no risk of delayed hemorrhage.

With most centers using some type of bypass to repair BAI, it is clear some surgeons are not comfortable performing aortic repair using the clamp-and-sew method. Using this method has been shown to be safe in a large multicenter study; however, predictors of morbidity in the form of paralysis were shown to be associated with cross-clamp times in excess of 30 minutes. With cross-clamp times being highly variable, depending on the experience of the surgeon and extent of the aortic injury (internationally, average cross-clamp times exceed 40 minutes), it may be prudent for surgeons not experienced with the clamp-and-sew method to use some form of bypass when repairing BAI acutely in the face of low-grade liver or spleen injuries.

This current study evaluates the safety of partial bypass with full heparinization in patients with concomitant aortic injury and low-grade liver or spleen injuries. Patients who received immediate repair of their aorta despite low-grade liver or spleen injuries had no difference in NOM failure of
their liver or spleen injuries compared with liver and spleen injury controls. When the Aorta L/S group was compared with patients with BAI without solid organ injuries, no increased morbidity was seen despite a higher ISS in the Aorta L/S group. The Aorta L/S group also had similar length of stay, transfusion requirements, complication rates, and mortality when compared with the Aorta group. Furthermore, none of the Aorta L/S group required operation to control bleeding from their solid organ injury after repair of the aorta.

This current study is retrospective and deals with a relatively select group of patients having grade I or II solid organ injury only, and therefore suffers from some limitations. The safety of heparinizing patients with higher grades of liver or spleen injury (III–V) was not studied, and no conclusions can be drawn for those patients. The high incidence of concomitant injuries, specifically, head injury and fractures, was not addressed. All patients with a documented intracranial injury were not operated on acutely, secondary to the risk of worsening a stable bleed; however, this has never been studied formally. Fourteen of 20 (70%) of the study group had concomitant fractures, and this was not addressed as a discrete variable; however, this did not delay repair of their aortic injury with full heparinization. Furthermore, no complications were attributed to these fractures. Therefore, aortic repair with full heparinization appears safe in this population, but the caveat must be mentioned that patients with more severe fractures are often hemodynamically unstable and would have selected themselves out of the population reviewed in this study.

By no means does this study alter the old dictum of exploring the abdomen first in unstable patients with both an aortic and intra-abdominal solid organ injury. Again, all patients studied were hemodynamically normal. However, this study does present convincing evidence that an aortic injury in association with low-grade liver or spleen injuries can be repaired acutely using partial bypass with full heparinization safely and effectively.

REFERENCES


EDITORIAL COMMENT

Dr. Santaniello and his associates from the Elvis Presley Trauma Center in Memphis have questioned the safety of anticoagulation during thoracic aortic trauma repair in patients who also have low-grade splenic liver injuries not requiring operation. Such nonoperative management for minor solid organ abdominal injuries is now a standard. Some of these patients will also require other operations elsewhere in the body, including those requiring heparinization during vascular reconstructions. Dr. Santaniello has demonstrated that for his patients with minor splenic injury, systemic heparinization did not result in greater blood replacement requirements compared with patients not undergoing heparinization. This information is very useful, considering for the limited scope of the patients presented.

The weakness of this paper relates to patients with more than minor splenic injury. Nonoperative therapy for patients with even grade 5 injuries to the liver and spleen is now occurring. Patients with extensive pelvic injury also require vascular reconstruction. This paper does not address the effect of heparinization during cardiopulmonary bypass for these more extensively injured patients. This paper must not be quoted in the future to support the safety of heparinization in patients with injuries more significant than minor splenic injury.

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