Patients Who Underwent Surgery for Blunt Abdominal Aortic Injury Have Higher Risk of Perioperative Mortality, Pneumonia, and Longer Hospital Length of Stay
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ABSTRACT

Objective: Blunt abdominal aorta injury (AAI) is uncommon and not well studied. This study is intended to compare the outcomes of patients with blunt AAI that were managed conservatively to those who were managed with surgery.

Design: Adult patients (>18 years) with blunt AAI were identified in National Trauma Databank (NTDB) (2002-2012) using ICD-9 and CPT codes. Patients with AAI secondary to penetrating injury were excluded. Patients were divided into two groups based on treatment modality (surgery versus observation). The surgery treatment group was further divided into patients treated with open repair and those treated with endovascular repair. Outcomes including 30-day mortality, morbidity and length of stay (LOS) were compared across the groups. Multivariable analysis was performed to adjust for possible confounding factors.

Results: Patients with blunt AAI (N=975) were identified and included in the study cohort. The majority of the patients were male (71.9%), mean age was 47 years, and overall mortality due to injury was 31%. Out of the patients with AAI injury, 21% (N=202) underwent surgery while 79% (N=773) were managed conservatively. Among the patients who underwent surgery, 81% (N=163) had open surgery and the remaining had endovascular surgery (N=39). Patients who underwent surgery had a higher injury severity score (ISS) (36.6 vs. 33.5, p=0.004), and different mechanism of injury (fall 6% vs. 12.4%, motor vehicle accident 79% vs. 77.6%, p=0.009). 30-day mortality (39.6% vs. 28.2%, p=0.002), pneumonia (14.4% vs. 8.4%, p=0.011), and lower extremity amputation (5% vs. 1%, p<.001) were significantly higher in patients who underwent surgery. Mean hospital LOS (17 vs. 12.4 days, p<.001) and mean ICU LOS (9.9 vs. 6.1 days, p<.001) were also significantly longer in patients that underwent surgery. Patients who were treated with endovascular repair had similar ISS to open repair but had significantly lower risk of mortality (30.8% vs. 41.7%, p=0.003). However, those who underwent endovascular repair had higher risk of pneumonia (23.1% vs. 12.3%, p=0.005) and lower extremity amputation (7.7% vs. 4.3%, p=0.001). In multivariable analysis, surgery was independently associated with risk of 30-day mortality (OR 1.8, 95% CI 1.2-2.7, p=0.009) and pneumonia (OR 1.8, 95% CI 1.1-3.0, p=0.02). Other factors associated with mortality were age (OR 1.1, p<0.001) and ISS (OR 1.1, p<0.001).

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The authors claim no conflicts of interest or disclosures.
AMSRJ 2017; 4(1):46-51
http://dx.doi.org/10.15422/amsrj.2017.03.013
Conclusion: Patients with blunt abdominal aortic injury have significant mortality and morbidity. Those with more severe injuries underwent surgical repair, and had significantly higher mortality, pneumonia and required longer length of stay compared to those were managed conservatively. Endovascular repair can be associated with better survival than open repair.

INTRODUCTION

Injury to the abdominal aorta is extremely rare and current literature exploring this type of injury is limited.1-3 Blunt abdominal aortic injury (AAI) accounts for about 5% of all traumatic aortic injuries.1-3 According to Rosengart and Zierler, this particular injury is associated with a mortality of 18% to 37%, partially due to a high incidence of the associated injuries4, for example crush injury to the bowel, lumbosacral spine fracture, abdominal wall transection, or spinal cord ischemia.11 While some of the causes of AAI include cycling accidents, repetitive direct blows to the abdomen, crush injuries and falls, it is often a result of high-speed motor vehicle crashes.1,5,6 It is thought that the mechanism of injury is either directly due to compression of the aorta or indirectly resulting from a sudden deceleration.6

The most common location of injury is below the inferior mesenteric artery (IMA),4,5,7 followed by at the level of the renal arteries, and finally between the IMA and bifurcation of the aorta.5 The presentation of injury varies and may include intimal disruption with or without thrombosis, intramural hematoma, aortic pseudoaneurysm, and transection with exsanguinating hemorrhage.9 Clinically, the most frequent presentation includes shock, abdominal pain,10 acute arterial insufficiency, neuromuscular deficits, and abdominal wall defect.9

Treatment options for BAAI are dependent on the nature of the injury.11 Consideration of overall clinical status, injury severity, and presentation are of great importance when determining a course of treatment.10 While minor contusions or intimal disruptions may be managed conservatively,11 open repair has been the treatment of choice for more severe injury management in the past.9 Most recently endovascular procedures have become available as an option for treatment.11 Current research on outcomes of conservative treatment versus surgical treatment shows that conservative treatment is associated with higher mortality compared to surgical management. However, the possibility exists that early death may prevent intervention in patients managed conservatively.2

The goal of this study is to compare the treatment approaches and outcomes of patients with blunt abdominal aortic injury using a national database, as well as to evaluate the trend and outcomes of endovascular repair as compared to open repair.

MATERIALS AND METHODS

Our study was a retrospective review of prospectively collected data in which we used data collected from the National Trauma Data Bank (NTDB) from 2002 to 2012. Adult patients with blunt AAI (aged ≥18 years) were identified using the International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes and Current Procedural Terminology (CPT) codes. Pediatric patients (<18 years old), patients with severe head injury (GCS <8), patients who succumbed to their injuries in the emergency room and those dead on arrival were excluded.

Patients were stratified into two groups based on treatment approach (Surgery versus Observation). Patients treated surgically were further stratified into those treated with open repair and those treated with endovascular repair. Patient demographic characteristics -
age, gender, race, and injury characteristics - injury mechanism, systolic blood pressure in the emergency department (ED) greater than 90, Injury Severity Score (ISS) and Glasgow Coma Scale (GSC) were reported and compared between the groups using chi-square test for categorical measures and t-test for continuous measures.

Primary outcome measures were 30-day death, pneumonia, lower extremity amputation, deep vein thrombosis (DVT), pulmonary embolism (PE), urinary tract infection (UTI), acute respiratory distress syndrome (ARDS), stroke, hospital length of stay (LOS) and intensive Care Unit (ICU) LOS. In bivariable analyses all outcome measures were compared between treatment groups using chi-square test for categorical measures and Gamma regression for hospital LOS and ICU LOS (due to highly skewed distribution of the outcome). Multivariable analyses were used to compare primary outcome measures between treatment groups adjusting for possible confounding effect of age, gender, race, mechanism of injury, systolic blood pressure in ED, ISS and GSC. Multivariable logistic regression was used for hospital mortality and pneumonia. The associations were reported via adjusted odds ratios (OR) with corresponding 95% confidence interval (95% CI). Multivariable Gamma regression was used for hospital LOS, and the associations were reported via adjusted means ratios (MR) with corresponding 95% CI. The data was evaluated using SAS 9.3 software (SAS Institute Inc., Cary, NC, USA) and p value <.05 was considered to be significant.

**RESULTS**

Patients with blunt AAI were identified and included in the study cohort (N=975); 450 patients (46.9%) were treated in an American College of Surgeons level I trauma center and 640 patients (66.3%) were treated at a university-affiliated hospital. Two hundred two patients (N=202, 20.7%) underwent surgery (open or endovascular repair) and 773 patients (N=773, 79.3%) were treated non-surgically (observation). The overall mean age of the patients in our study was 46.7 years of age. The majority of the patients included were male and most patients were Caucasian. The ISS was found to be greater in patients treated surgically compared to those that were observed (36.6±13.1 vs 33.5±13.3; p=0.004) (Table 1).

Overall 30-day mortality due to AAI was 31% and was significantly higher in patients treated with surgery (39.6% vs. 28.2%, p=0.002). Pneumonia (14.4% vs. 8.4%, p=0.01) and lower extremity amputation (5% vs. 1%, p.<.001) were also significantly higher in surgery cohort when compared patients who were observed. Mean hospital LOS (17±18.9 vs. 12.4±16.6 days, p=0.001) and mean ICU LOS (9.9±13.3 vs. 6.1±9.4 days, p.<.001) were longer in patients who were treated with surgery (Table 2).

Of the 202 surgical patients, 163 cases were open repair and 39 were endovascular repair. Patients treated with open surgery had
significantly higher perioperative mortality (42% vs. 31%, p=0.003) but had lower rates of lower extremity amputation (4% vs. 8%, p<0.001) and pneumonia (12% vs. 23%, p=0.005) as compared to endovascular repair. Overall hospital LOS and ICU LOS were greater in endovascular patients compared to open repair patients (Table 3).

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Overall (N=175)</th>
<th>Observation (N=73)</th>
<th>Surgery (N=282)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality, n(%)</td>
<td>298 (30.6%)</td>
<td>218 (28.2%)</td>
<td>80 (39.6%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Lower Extremity Amputation, n(%)</td>
<td>17 (1.7%)</td>
<td>7 (0.9%)</td>
<td>10 (5%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pneumonia, n(%)</td>
<td>94 (9.6%)</td>
<td>65 (8.4%)</td>
<td>29 (14.4%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Urinary tract infection, n(%)</td>
<td>22 (2.3%)</td>
<td>17 (2.2%)</td>
<td>5 (2.5%)</td>
<td>0.814</td>
</tr>
<tr>
<td>Deep venous thrombosis, n(%)</td>
<td>37 (3.8%)</td>
<td>28 (3.6%)</td>
<td>9 (4.5%)</td>
<td>0.581</td>
</tr>
<tr>
<td>Acute respiratory distress, n(%)</td>
<td>63 (6.5%)</td>
<td>49 (6.3%)</td>
<td>14 (6.9%)</td>
<td>0.761</td>
</tr>
<tr>
<td>Pulmonary embolism, n(%)</td>
<td>17 (1.7%)</td>
<td>12 (1.6%)</td>
<td>5 (2.5%)</td>
<td>0.373</td>
</tr>
<tr>
<td>Stroke</td>
<td>8 (0.8%)</td>
<td>7 (0.9%)</td>
<td>1 (0.5%)</td>
<td>0.565</td>
</tr>
</tbody>
</table>

Overall Length of Stay (days)

- Mean ± SD: 13.3 ± 17.4
- Mean ± SD: 12.4 ± 16.6
- Mean ± SD: 17 ± 18.9

ICU Length of Stay (days)

- Mean ± SD: 6.9 ± 10.4
- Mean ± SD: 6.1 ± 9.4
- Mean ± SD: 9.9 ± 13.3

Table 2: Perioperative outcomes of patients with blunt abdominal aortic injury

Multivariable analysis confirmed surgery was independently associated with higher odds of mortality (OR 1.8, 95% CI 1.2-2.7, P=0.009) and pneumonia (OR 1.8, 95% CI 1.1-3 P=0.02) (Figure 1). Other factors associated with increased mortality were age (OR 1.04, 95%CI 1.03-1.05, P<0.001) and ISS (OR 1.05, 95%CI 1.04-1.07, P<0.001). Higher GCS (OR 0.9, 95%CI 0.8-0.9, p<0.001) and higher systolic blood pressure on presentation (OR 0.3, 95%CI 0.2-0.5, p<0.001) were associated with lower mortality. Surgery was independently associated with 30% increase of mean hospital LOS (MR 1.3, 95% CI 1.1-1.6, P=0.003) (Figure 2).

**DISCUSSION**

We found that the mortality associated with blunt AAI was substantial, with significant difference in the treatment modality of the patient. Patients who underwent surgical treatment for their blunt AAI had significantly higher perioperative mortality, morbidity and hospital LOS compared to those who were managed conservatively. Patients who were treated with endovascular repair had lower mortality compared to those who underwent open repair.

Based on our study, 28.2% of patients with blunt AAI were observed and 39.6% of patients treated surgically died as a consequence of their injury. While there is a significant difference between treatment approaches, the mortality for both groups is substantial. In a similar study carried out by de Mestral et al., patients managed non-operatively had a significantly different mortality rate of 31% compared to 12% of surgically treated patients. As to morbidity, they found that acute respiratory distress syndrome was the most common complication overall, with an incidence of 11%, followed by
pneumonia with an incidence of 9%.4

We would like to note that the mortality results found by de Mestral et al differ from ours in that patients in their study that underwent conservative treatment had higher rates of mortality. It is possible that the differing results from our study and de Mestral’s originate from differences in study methods. While both studies used the same database, de Mestral’s only covered a 2-year period. Our study covered a period of 10 years, which allowed us to include a greater number of patients compared to theirs. Additionally, their exclusion criteria differed from ours in a few ways. Their study excluded patients younger than 16 and those with an ISS of less than 16, where as ours excluded those younger than 18 and did not use ISS as an exclusion criteria. Our study did, however, exclude those with severe head injuries (GCS <8).

With the exception of GCS and age, we found significant differences in the ED assessment of surgical versus non-surgical patients. Those that had surgery had a more severe ISS. While the most common mechanism of injury for both groups was MVT, the data is statistically significant between patients treated surgically and those treated conservatively. There were no significant differences between non-surgery and surgery groups in terms of gender and race demographics.

As to complications, it was found that patients that underwent surgery experienced a greater length of stay in the hospital and ICU. Mortality was the most common complication of both surgical and non-surgical groups, and is statistically significant. Other statistically significant complications included pneumonia and amputation. When comparing different patient groups based on surgical approach, we found that patients that were treated with open repair had significantly higher rates of amputation and pneumonia, as well as a higher mortality rate when compared to endovascular repair. Patients treated with open repair had a lower incidence of ARDS when compared to endovascular repair. When concerning overall hospital and ICU length of stay, patients undergoing endovascular repair had significantly longer lengths of stay both in the hospital and ICU.

Our study found that patients who were observed had a shorter overall hospital LOS and ICU los compared to those who received surgery. The study carried out by de Mestral et all also addressed hospital LOS, with a mean of 6 days for observed patients and a mean of 13 days for patients that underwent surgery.2 Another study carried out by Michaels et al. consisting of 7 patients that were surgically managed showed an LOS of 30.86 ± 19.40 days (mean ± standard deviation) and an ICU LOS of 14.29 ± 16.02 days (mean ± standard deviation). One of the seven patients died after spending 3 days in the hospital, which is a possible explanation for the large standard deviation in both LOS and ICU LOS.12 A separate study done by Reddy et al. looked at LOS based on injury grade and treatment. They proposed the following classification system: Grade Ia injuries were those with intimal tear, grade Ib were those with intramural hematoma, grade II were those with intimal injury and periaortic hematoma, grade IIIa were those with partial aortic transection with pseudoaneurysm, grade IIIb were those with multiple aortic injuries, and grade IV were those with free rupture. Grade Ia and II injuries did not undergo surgery and had an overall LOS of 19±10 days and 7 days respectively. Grade IIIa, IIIb, and IV were treated surgically, and had an overall LOS of 19±9 days, 21 days, and 30±12 days respectively. The authors of this study noted that ISS became progressively higher as the grade of aortic injury increased. They did not look at ICU LOS.13

Our study is limited due to its retrospective nature. In addition, since the NTDB has a disproportionate number of larger hospitals, it may not represent all trauma hospitals in the
nation. NTDB samples are also submitted voluntarily by hospitals that participate in the database, making the data subject to selection bias. A prospective randomized study would have fewer sources of bias. Due to the rarity of abdominal aortic injury, a prospective study would be more difficult to carry out.

While there are limitations to our study, it encompasses a large number of patients with abdominal aortic injury found using the NTDB. Even with a possibility of selection bias, the NTDB would better represent the population compared to a study focused solely on the patient population of a specific hospital.

**CONCLUSION**

Patients with blunt abdominal aortic injury have significant mortality and morbidity. Patients who required surgical treatment for injuries had significantly higher mortality, morbidity and longer hospital length of stay compared to those who were managed conservatively. Endovascular repair, if feasible, can be associated with better survival than open repair and should be considered in patients that are candidates for endovascular treatment.

**REFERENCES**