Dramatic Shift in the Primary Management of Traumatic Thoracic Aortic Rupture

Darren R. Lebl, MD; Rochelle A. Dicker, MD; David A. Spain, MD; Susan I. Brundage, MD, MPH

Hypothesis: Traumatic thoracic aortic injury (TAI) is traditionally treated with immediate surgery. Previously published studies have established the safety and efficacy of treating TAI with endovascular stents. Our hypothesis was that stents are supplanting operative repair as the primary therapy for TAI.

Design: Retrospective cohort.

Setting: University level I trauma center.

Patients and Methods: Blunt trauma patients admitted to a level I trauma center diagnosed with TAI between September 1997 and November 2003 were identified from an institutional trauma registry (N=25). Data were abstracted from medical records and analyzed. Three groups were defined: surgical repair (cardiopulmonary bypass or clamp and sew) (n=10); medical management (n=8); and endovascular stent (n=7).

Results: Prior to 2002, 9 (75%) of 12 patients were treated by surgical repair, 2 (17%) by medical management, and 1 (8%) by endovascular stent. Since 2002, 1 patient (8%) was treated by surgical repair, 6 (46%) by medical management, and 6 (46%) by endovascular stent. Injury Severity Scores were comparable between the surgical cohort (mean±SEM score, 34.9±3.4), stent placement (35.1±3.7), and medical management (29.9±2.8) (P=.48). Overall survival was 80% with no differences in morbidity or mortality. The stented group had shorter hospital lengths of stay compared with surgical management (28 vs 46 days) (P<.05). The 1 operative case since 2002 was a combined arch/innominate injury that anatomically precluded stent placement.

Conclusion: Initial reports suggested thoracic aortic stents as an alternative for injured patients with prohibitive operative risks. Our data suggest stent placement is quickly evolving into the primary therapy for TAI across all Injury Severity Score profiles.

Arch Surg. 2006;141:177-180

The surgical standard of care for patients with traumatic thoracic aortic injury (TAI) has traditionally been early operative intervention with thoracotomy and graft interposition or primary repair. Despite advances in cardiopulmonary bypass and perioperative care, the risks of bleeding, paraplegia, stroke, renal failure, and pulmonary insufficiency remain. The risk of postoperative paraplegia from aortic cross-clamping has been reported to range between 9% and 19% following open repair.1-3 The relative safety and efficacy of less-invasive endografting in the repair of aneurysmal aortic disease4 has encouraged many centers to investigate endovascular stent graft (EVSG) placement in the emergent setting of TAI. Preliminary reports in the literature to date suggest that EVSGs reduce the risk of paraplegia associated with open repair of TAI5-13 and are an option for patients at prohibitive operative risk.

The objective of this study was to retrospectively analyze the treatment options (open repair, medical management, and EVSG) and their respective outcomes for TAI at a level I trauma center. We hypothesized that despite a paucity of data in the literature on their safety and efficacy, EVSGs are rapidly becoming the standard of care as primary management of TAI.

METHODS

We performed a retrospective analysis of blunt trauma patients admitted to our level I trauma center between September 1997 and November 2003. Hospital records for all patients admitted with a diagnosis of TAI were analyzed. Clinical parameters included age, mechanism of injury, Injury Severity Score, Glasgow Coma Scale, diagnostic modality (chest x-ray, computed tomographic angiogram, or aorto-
gram), anatomic description of aortic injury, primary treatment, other injuries directly related to blunt trauma, other inpatient procedures, existing comorbidities, intensive care unit length of stay, hospital length of stay, mortality, and cause of death.

Three groups were defined based on primary treatment of TAI: (1) thoracotomy and open surgical repair (cardiopulmonary bypass or clamp and sew); (2) medical management only; and (3) endovascular stent placement. Concomitant injuries precluding operative intervention such as severe comorbid head, chest, abdominal, and/or orthopedic injuries were contraindications to traditional operative repair. Medical treatment consisted of a β-blocker (ie, esmolol hydrochloride, metoprolol tartrate, or labetalol hydrochloride) on occasion supplemented by enalapril to keep mean arterial pressure from 60 to 70 mm Hg both during the hospitalization and after discharge.

All data analysis was performed using Stata 8.0 statistical software (Stata Corp, College Station, Tex). Data are presented as mean±SEM. The 2-sided t test was used to examine the difference among the continuous variables: Injury Severity Score, hospital length of stay, and intensive care unit length of stay. The categorical variable mortality was analyzed using a 2-sided Fisher exact test.

### RESULTS

Prior to 2002, 9 (75%) of 12 patients were treated by surgical repair, 2 patients (17%) were treated by medical management, and 1 patient (8%) was treated by EVSG. Since 2002, 1 patient (8%) was treated by surgical repair, 6 (46%) by medical management, and 6 (46%) by EVSG. Injury Severity Scores were comparable between the surgical cohort (mean±SEM score, 34.9±3.4), stent placement (35.1±3.7), and medical management (29.9±2.8) (P = .48). Overall survival was 80% with no differences in morbidity or mortality (Table). Mean±SEM age for surgical management vs nonoperative management (combined medical management and EVSG) was 39±5 years vs 56±5 years (P <.04). The mean±SEM age comparing the groups as 3 cohorts, surgical management (39±5 years), medical management (33±7 years), and EVSG (59±8 years), did not reach significance (P = .10). Mean±SEM Injury Severity Score for surgical management (35±3) vs nonoperative management (combined medical management and EVSG) (33±6) was not significantly different (P = .8). There were no significant differences in Head Abbreviated Injury Scale score when comparing operative management (mean±SEM score, 1.0±0.50) vs nonoperative management (combined medical management and EVSG, mean±SEM score, 1.4±0.41) (P = .6). The stented group had shorter hospital lengths of stay compared with surgical management (28 vs 46 days) (P <.05). The 1 operative case since 2002 was a combined arch/innominate injury that anatomically precluded stent placement. The locations of traumatic aortic injuries are shown in the Figure.

### COMMENT

In patients with severe TAI, multiple injuries (in our patient population, a mean Injury Severity Score ranging from 29.9 to 35.1) may frequently preclude traditional operative management. Preliminary studies that EVSGs reduce the morbidity associated with traditional thoracotomy and graft interposition in patients with TAI have been encouraging.5,6,9,14-21 We hypothesized that endovascular stents are supplanting operative repair as the primary therapy for TAI. The present study demonstrates that at our institution, EVSGs are rapidly becoming routine first-line therapy for blunt trauma patients with TAI. The level of risk that is considered acceptable for a patient with TAI to undergo open surgical repair is not firmly

### Table. Complications Following Management of Traumatic Aortic Injury*

<table>
<thead>
<tr>
<th>Complication</th>
<th>Thoracotomy (n = 10)</th>
<th>Medical Management (n = 8)</th>
<th>Endovascular Stent (n = 7)</th>
<th>Total (N = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult respiratory distress syndrome</td>
<td>2 (20)</td>
<td>0</td>
<td>1 (14)</td>
<td>3 (12)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2 (20)</td>
<td>0</td>
<td>0</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0</td>
<td>0</td>
<td>1 (14)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1 (10)</td>
<td>0</td>
<td>0</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Neurological complications</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mortality</td>
<td>2 (20)</td>
<td>2 (25)</td>
<td>1 (14)</td>
<td>5 (20)</td>
</tr>
</tbody>
</table>

*All values are number (percentage).

![Figure. Location of traumatic aortic injuries. Numbers in each set of parentheses indicate the number of patients treated by surgical repair, the number treated by medical management, and the number treated by endovascular stent, respectively.](http://archsurg.jamanetwork.com/pdfaccess.ashx?url=/data/journals/surg/9604/)
established. Therefore, definition of a nonsurgical candidate in the context of TAI has been dynamic. Existing criteria for aortic endovascular stenting have evolved from a primarily aneurysmal indication to include patients with TAI with prohibitive operative risks. In this series, tears arising in the ascending aorta or extending proximally into the aortic arch required surgery. Injuries at or distal to the left subclavian were primarily treated with nonoperative management, either EVSG or medical management after 2001, whereas prior to 2001, similar injuries of the descending aorta underwent operative repair.

ADVANTAGES AND RISKS OF TAI TREATMENT OPTIONS

Thoracotomy followed by primary surgical repair of TAI offers definitive treatment without the introduction of the exogenous material present in an EVSG, which has unknown acute and long-term risks. However, the risks of aortic cross-clamping or the use of cardiopulmonary bypass are substantial in the trauma patient with multiple organ-system injuries. Bleeding, renal failure, pulmonary insufficiency, and neurological impairment are operative risks that have the potential to be reduced by a less invasive EVSG approach to TAI.

Medical management alone offers the least invasive approach to the nonsurgical patient with TAI. However, the failure to provide any definitive type of treatment leaves the underlying risk of acute aortic rupture. The less invasive nature of endoluminal aortic transection repair offers the clear advantage of the avoidance of thoracotomy and the associated recovery period. This is evidenced in the present study by the shorter hospital length of stay seen in patients treated by EVSG than those undergoing open surgical repair despite similar Injury Severity Score profiles.

At these early stages in the development of endovascular technology, a new set of risks is becoming evident that will require further study. Differing patient populations need to be considered if EVSGs are to evolve from a primarily aneurysmal indication into the standard of care for traumatic aortic transection. Several groups have reported that EVSGs are relatively innocuous in the short-term course encountered by elderly patients with aneurysmal pathologic abnormalities. However, it is the long-term risks of EVSG treatment that will be of particular importance in the younger patient population typically encountered in the trauma setting. For instance, the medical consequences of stent-wire fractures, found in as many as 8% of patients treated for aneurysmal pathologic abnormalities, remain to be determined on a long-term basis. The incidence of endoleak, fistula formation, and late stent migration years or decades after stent placement may make open surgical therapy a more desirable option.

In the multiple trauma patient, the additional operative risk of turning the patient to the lateral decubitus position for thoracotomy can also be avoided by EVSG placement. This advantage of keeping the patient in the supine position is especially important given the overlapping spinal injury patient population with spinal injuries frequently seen in TAI.

LIMITATIONS OF EVSG TECHNOLOGY

The diameter of existing commercially available stents is designed for the aneurysmal aortas and not the small, nonaneurysmal aortas that are encountered in blunt trauma patients. In addition, the altered anatomy of the traumatically transected aorta will further stress the design of available stents. The current endovascular strategy for the management of TAI consists of using hand-made grafts, which may alter their structural integrity. Angulation or kinking of the graft may increase the risk of breakage, incorrect placement of the graft, or stent collapse or migration. The altered anatomy and physiology seen in the trauma patient will necessitate stents designed and tested specifically for this purpose. According to our data, the indications for aortic stent grafting in the trauma patient have been liberalized from aneurysm treatment to include patients with blunt TAI even though the learning curve has not been well established.

LIMITATIONS OF THE PRESENT STUDY

The current study was conducted at a single center with a large referral base and highly specialized interventional radiology, cardiac surgery, and trauma surgery teams. Dynamic emergency department referral patterns have yielded an increase in the volume of trauma patients seen at our center of approximately 40% since 2001. During the last study period of 1 year (2002-2003), there were 13 cases with aortic rupture while during the much longer early study period of 5 years (1997-2002), there were a total of only 12 cases. As it is unlikely that there was a dramatic increase in the incidence of aortic ruptures, one possibility is the much more liberal computed tomographic evaluation of blunt trauma patients resulting in more diagnoses of minor aortic tears, which could be safely managed nonoperatively. The cases diagnosed during the first study period could have been major ruptures not amenable to nonoperative management, which would explain the shift in management away from traditional operative repair. Certainly, the increase in cases seen in the last period of the study (2002-2003) was not secondary to an increase in the incidence of aortic ruptures. In actuality, the majority of the aortic injuries in the latter period of the study were transferred to the institution for evaluation (12/13 or 92%) and of a severe nature. The increased numbers of aortic injuries were not the result of an increased sensitivity during computed tomographic screening of direct admissions because only 1 of 13 aortic injuries was a direct admission during 2002-2003. The great increase in numbers of aortic injuries in the latter part of the study period is most likely due to a change in referral patterns in northern California based on increased hospital commitment to a designated trauma service and awareness of the capacity for nonoperative management at Stanford given the skill of the interventional radiology, cardiac surgery, and trauma surgery teams. In contrast, during the earlier time period of 1997-2001, 6 (50%) of 12 patients were transferred. A significant increase in transfers to our tertiary center occurred in August 2001, coinciding
with the increased hospital commitment to the trauma service.

To date, EVSGs are being used in a small number of tertiary centers. This brings into question the widespread applicability of our data to trauma patients at other institutions. Recent advances in trauma and critical care may also be a confounding factor in the retrospective study of treatment modalities from 1997 to 2003. Perhaps more severely injured patients with TAI and contraindications to traditional operative interventions are surviving to reach the hospital and are not candidates for traditional repair secondary to their concurrent injuries. In addition, statistical limitations exist in a retrospective study with a limited number of patients, predisposing our analysis to a type II error.

CONCLUSION

The potential for a less invasive endoluminal approach to the injured aorta holds much promise, and management decisions have shifted to favor nonsurgical repair of TAI in recent years. Blunt trauma patients with multiple injuries who were unlikely to tolerate operative intervention had initially pushed management decisions away from traditional open surgical repair of TAI to management by EVSG or medication alone. These findings suggest a shift in the standard of care for blunt trauma patients with TAI toward nonoperative management despite a paucity of data on both acute and long-term outcomes.

Accepted for Publication: May 19, 2005.
Correspondence: Susan Brundage, MD, MPH, Department of Surgery, Stanford University Medical Center, 300 Pasteur Dr, Room H3680, Stanford, CA 94305-5655 (sbrundage@stanford.edu).
Previous Presentation: This data was a podium presentation at the Annual Meeting of the Western Surgical Association; November 10, 2004; Lake Las Vegas, Nev.

REFERENCES