Traumatic Rupture of the Thoracic Aorta

HOT TOPIC SYMPOSIUM: Aortic Emergencies

CIRSE 2016

Sunday, September 11, 2016

Michael D. Dake, M.D.
Thelma and Henry Doelger Professor
Department of Cardiothoracic Surgery
Stanford University School of Medicine
Falk Cardiovascular Research Center

Michael Dake, MD

Within the past 12 months, the presenter or their spouse/partner have had a financial interest/arrangement or affiliation with the organization listed below.

- Research/Research Grants, Clinical Trial Support
  - W. L. Gore (major)
  - Cook Medical (major)
- Consulting Fees/Honoraria
  - W. L. Gore
  - Cook Medical
  - Abbott Vascular (minor)
  - Medtronic (minor)
  - Cardinal Health (minor)
- Equity Interests/Stock Option
  - TriVascular (minor)
  - Intact Vascular (minor)
  - Arsenal (minor)
  - 480 Medical (minor)
  - PQ Bypass (minor)
  - AneuMed (minor)
- Officer, Director, Board Member or other Fiduciary Role
  - VIVA Physicians Group
- Speaker's Bureau
  - None

Traumatic Aortic Injury

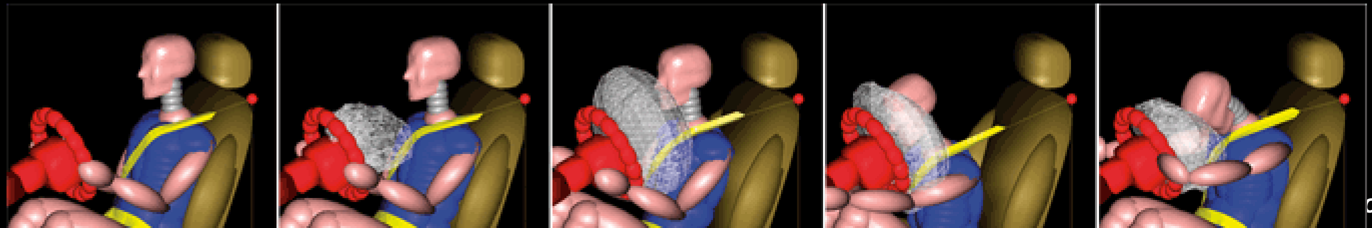
What we'll cover today

- Background facts, anatomy and pathophysiology
- Classification and frequency of various types of injury
- When to treat considerations
- Results of conservative, open surgery and endovascular therapies
- Summary

Blunt Traumatic Aortic Injury

Epidemiology

- 2% of patients who sustain blunt thoracic trauma
  - Rapid Deceleration
  - Examples: Car, motorcycle and aircraft crashes, falls, and crush injuries
- 81 % secondary to MVA
- In US, second leading cause of death for individuals aged between 4 to 34. (#1 is head injury)
- Only ~20% of patients with blunt aortic injury survive long enough to be treated



Location, Location, Location

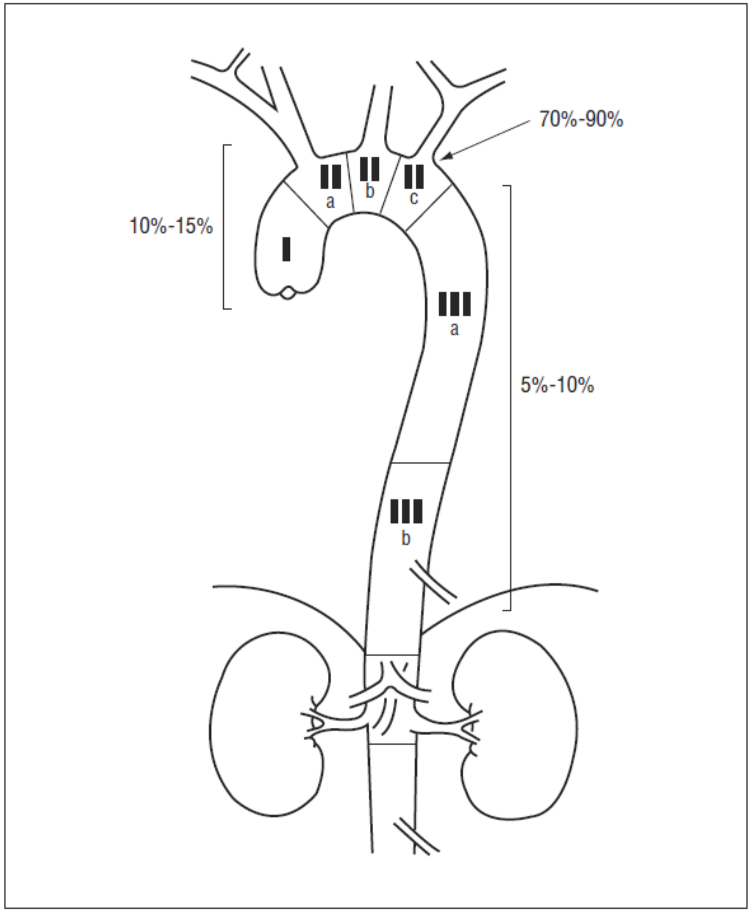
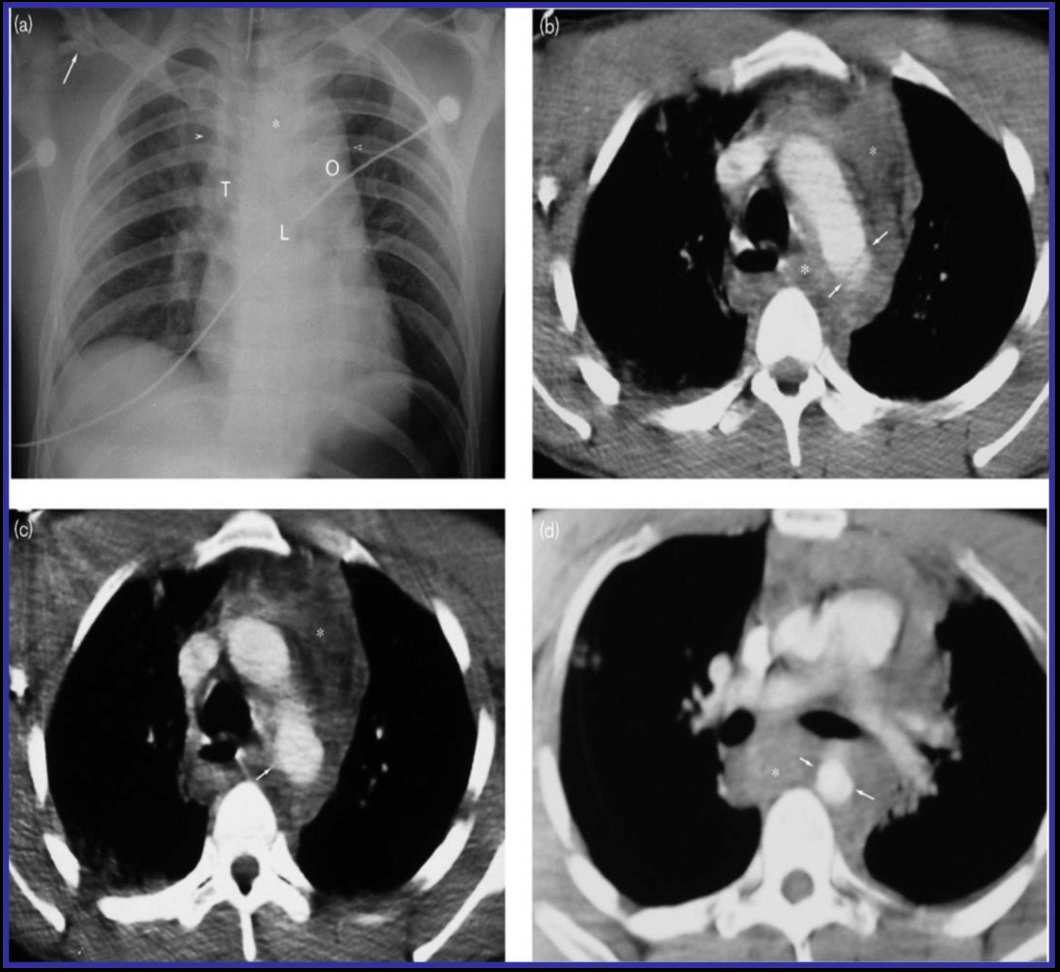
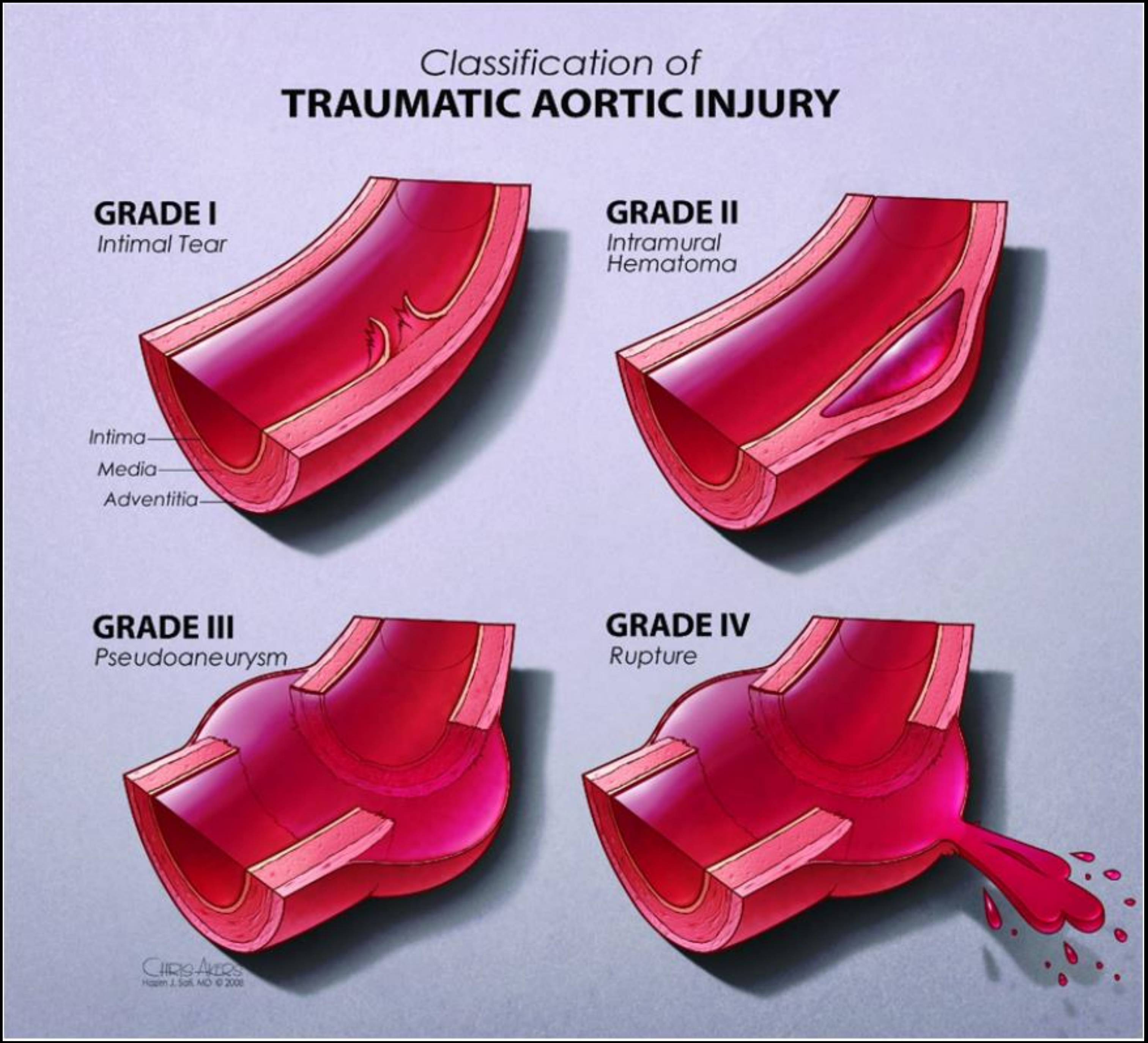


Figure 1. Various locations of blunt aortic injury.

Imaging of Aortic Injury

- <u>CXR:</u>
  - mediastinal widening
  - tracheal deviation
  - displacement left bronchus
  - obliteration of aorto-pulmonary window.
  - small apical cap.
  - rib fractures
- CT:
  - intimal flap
  - small pseudo-aneurysm is visible
  - small calibre of the aorta from more proximal rupture




Classification of
TRAUMATIC AORTIC INJURY
GRADE I
Intimal Tear
Intima
Media
Adventitia
GRADE II
Intramural
Hematoma
GRADE III
Pseudoaneurysm
GRADE IV
Rupture

Results of a multicenter, prospective trial of thoracic endovascular aortic repair for blunt thoracic aortic injury (RESCUE trial)

Ali Khoynezhad, MD, PhD,[a] Ali Azizzadeh, MD,[b] Carlos E. Donayre, MD,[c] Alan Matsumoto, MD,[d] Omaida Velazquez, MD,[e] and Rodney White, MD,[c] on behalf of the RESCUE* investigators, *Los Angeles and Torrance, Calif; Houston, Tex; Charlottesville, Va; and Miami, Fla*

Objective: To evaluate the early outcomes of patients undergoing thoracic endovascular aortic repair for blunt thoracic aortic injuries.

Methods: A prospective, nonrandomized, multicenter trial using the Medtronic Valiant Captivia stent graft was conducted at 20 sites in North America. Fifty patients with blunt thoracic aortic injuries were enrolled between April 2010 and January 2012 and will be followed for 5 years. The injuries were classified into categories (grades I-IV) based on severity: intimal tear, intramural hematoma, pseudoaneurysm, or rupture. The primary end point was 30-day all-cause mortality. Secondary end points were adverse events occurring within 30 days that were related to the procedure, device or aorta, and aortic-related mortality. Technical success was measured as successful device delivery and deployment.

Results: Seventy-six percent (38/50) of patients were male with mean age of 41 ± 17 years. Fifty-one Medtronic Valiant Captivia thoracic stent grafts and a single Talent thoracic stent graft were implanted within a median of 1.0 days following injury (mean, 1.8 ± 4.0 days). Seventy percent (35/50) of aortic injuries were grade III or higher, including one patient with free rupture. Mean injury severity score was 38 ± 14. Fifty-four percent of stent grafts were ≤26 mm (28/52). The left subclavian artery was completely covered in 40% of patients (20/50) and partially covered in 18% of patients (9/50). Four patients underwent subclavian artery revascularization: one at the time of the endograft procedure and three others after developing arm ischemia after the initial endograft procedure. Cerebral spinal fluid was drained in two patients. The median procedure time was 91 minutes, and median hospital stay was 12 days. There was 100% successful device delivery and deployment. Four (8%) patients died within 30 days. Nonfatal adverse events within 30 days that were related to the procedure, device, or aorta were experienced by 12% (6/50) of patients. No nonfatal adverse events related to the device were reported; a single death was conservatively adjudicated as device-, procedure-, and aorta-related because of insufficient information. No patient developed spinal cord injury, and there were no cerebrovascular accidents. However, one patient had an anoxic brain injury following aortic rupture. No patient underwent conversion to open repair or required an endovascular reintervention.

Conclusions: Based on the early outcomes, the Medtronic Valiant Captivia stent graft appears to be a promising treatment modality for blunt thoracic aortic injuries. Long-term follow-up is necessary to substantiate the effectiveness of thoracic endovascular aortic repair in treatment of blunt thoracic aortic injuries. (J Vasc Surg 2013;57:899-905.)

Table II. Injury characteristics

Extent of overall injuries	
Assigned injury severity score	
Mean ± SD	38 ± 14
Median (range)	35 (13-75)
Extent of aortic injury	
Grade I: intimal tear	18% (9/50)
Grade II: intramural hematoma	12% (6/50)
Grade III: aortic pseudoaneurysm	68% (34/50)
Grade IV: free rupture	2% (1/50)
Associated traumatic injuries	
Head injury	48% (24/50)
Neurologic deficits	12% (6/50)
Long B1 fracture	38% (19/50)
Pelvic fracture	40% (20/50)
Scapula fracture	8% (4/50)
Unstable C/T/L spine fractures	14% (7/50)
Abdominal injury[a]	58% (29/50)
Lung injury	70% (35/50)
Rib fracture	64% (32/50)
Sternum fracture	6% (3/50)
Other	50% (25/50)

SD, Standard deviation.

[a]Solid organ, bowel, bladder, or diaphragm injury.

Parameters for successful nonoperative management of traumatic aortic injury

Joseph Rabin, MD,[a] Joe DuBose, MD,[a] Clint W. Sliker, MD,[b] James V. O'Connor, MD,[a] Thomas M. Scalea, MD,[a] and Bartley P. Griffith, MD[c]

Objective: Blunt traumatic aortic injury is associated with significant mortality, and increased computed tomography use identifies injuries not previously detected. This study sought to define parameters identifying patients who can benefit from medical management.

Methods: We reviewed 4.5 years of blunt traumatic aortic injuries. Injury was classified as grade I (intimal flap or intramural hematoma), II (small pseudoaneurysm <50% circumference), III (large pseudoaneurysm >50% circumference), and IV (rupture/transection). Secondary signs of injury included pseudocoarctation, extensive mediastinal hematoma, and large left hemothorax. Follow-up, including computed tomography, was reviewed.

Results: We identified 97 patients: 31 grade I, 35 grade II, 24 grade III, and 7 grade IV; 67(69%) male; mean age 47 ± 18.8 years, mean Injury Severity Score 38.8 ± 14.6; overall survival 76 (78.4%). Secondary signs of injury were found in 30 patients. Overall, 52 (53.6%) underwent repair, 45 undergoing thoracic endovascular aortic repair, with 2 (2.22%) procedure-related deaths, and 7 undergoing open repair. Five patients undergoing thoracic endovascular aortic repair required 7 additional procedures. In 45 medically managed patients, there were 14 deaths (31%), all secondary to associated injuries. Injury Severity Scores of survivors and nonsurvivors were 33 ± 10.8 and 48.6 ± 12.8, respectively ($P < .001$). Follow-up showed resolution or no change in 21 (91%) and a small increase in 2 grade I injuries.

Conclusions: All blunt traumatic aortic injury does not necessitate repair. Stratification by injury grade and secondary signs of injury identifies patients appropriate for medical management. Grade IV injury necessitates emergency procedures and carries high mortality. Grade III injury with secondary signs of injury should be urgently repaired; patients without secondary signs of injury may undergo delayed repair. Grade I and II injuries are amenable to medical management. (J Thorac Cardiovasc Surg 2014;147:143-50)

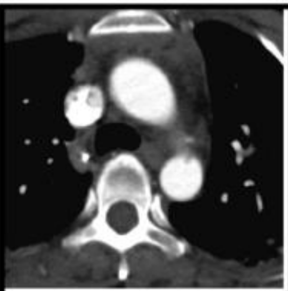
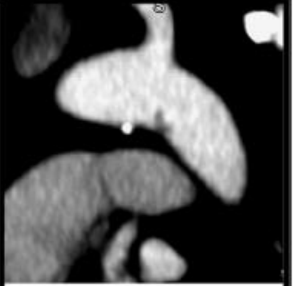
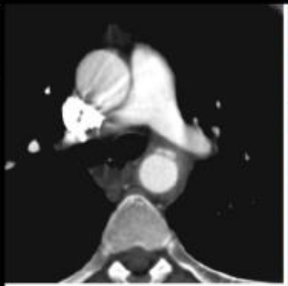
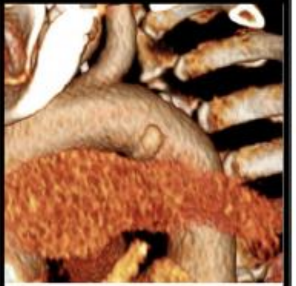
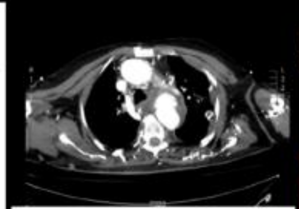
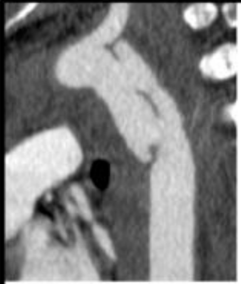
Grades of Aortic Injury			
Grade I	Intimal tear or intramural hematoma		
Grade II	Small pseudoaneurysm (less than 50% circumference)		
Grade III	Large pseudoaneurysm (more than 50% circumference)		
Grade IV	Rupture or transection		

FIGURE 1. Computed tomographic imaging demonstrating the grades of aortic injury.

Parameters for successful nonoperative management of traumatic aortic injury

Joseph Rabin, MD,[a] Joe DuBose, MD,[a] Clint W. Sliker, MD,[b] James V. O'Connor, MD,[a] Thomas M. Scalea, MD,[a] and Bartley P. Griffith, MD[c]

Objective: Blunt traumatic aortic injury is associated with significant mortality, and increased computed tomography use identifies injuries not previously detected. This study sought to define parameters identifying patients who can benefit from medical management.

Methods: We reviewed 4.5 years of blunt traumatic aortic injuries. Injury was classified as grade I (intimal flap or intramural hematoma), II (small pseudoaneurysm <50% circumference), III (large pseudoaneurysm >50% circumference), and IV (rupture/transection). Secondary signs of injury included pseudocoarctation, extensive mediastinal hematoma, and large left hemothorax. Follow-up, including computed tomography, was reviewed.

Results: We identified 97 patients: 31 grade I, 35 grade II, 24 grade III, and 7 grade IV; 67(69%) male; mean age 47 ± 18.8 years, mean Injury Severity Score 38.8 ± 14.6; overall survival 76 (78.4%). Secondary signs of injury were found in 30 patients. Overall, 52 (53.6%) underwent repair, 45 undergoing thoracic endovascular aortic repair, with 2 (2.22%) procedure-related deaths, and 7 undergoing open repair. Five patients undergoing thoracic endovascular aortic repair required 7 additional procedures. In 45 medically managed patients, there were 14 deaths (31%), all secondary to associated injuries. Injury Severity Scores of survivors and nonsurvivors were 33 ± 10.8 and 48.6 ± 12.8, respectively ($P < .001$). Follow-up showed resolution or no change in 21 (91%) and a small increase in 2 grade I injuries.

Conclusions: All blunt traumatic aortic injury does not necessitate repair. Stratification by injury grade and secondary signs of injury identifies patients appropriate for medical management. Grade IV injury necessitates emergency procedures and carries high mortality. Grade III injury with secondary signs of injury should be urgently repaired; patients without secondary signs of injury may undergo delayed repair. Grade I and II injuries are amenable to medical management. (J Thorac Cardiovasc Surg 2014;147:143-50)

A new classification scheme for treating blunt aortic injury

Benjamin W. Starnes, MD, FACS,[a] Rachel S. Lundgren, MD,[a] Martin Gunn, MBChB,[b] Samantha Quade, MD,[a] Thomas S. Hatsukami, MD,[a] Nam T. Tran, MD,[a] Nahush Mokadam, MD,[c] and Gabriel Aldea, MD,[c] *Seattle, Wash*

Background: There are numerous questions about the treatment of blunt aortic injury (BAI), including the management of small intimal tears, what injury characteristics are predictive of death from rupture, and which patients actually need intervention. We used our experience in treating BAI during the past decade to create a classification scheme based on radiographic and clinical data and to provide clear treatment guidelines.

Methods: The records of patients admitted with BAI from 1999 to 2008 were retrospectively reviewed. Patients with a radiographically or operatively confirmed diagnosis (echocardiogram, computed tomography, or angiography) of BAI were included. We created a classification system based on the presence or absence of an aortic external contour abnormality, defined as an alteration in the symmetric, round shape of the aorta: (1) intimal tear (IT)—absence of aortic external contour abnormality and intimal defect and/or thrombus of <10 mm in length or width; (2) large intimal flap (LIF)—absence of aortic external contour abnormality and intimal defect and/or thrombus of ≥10 mm in length or width; (3) pseudoaneurysm—presence of aortic external contour abnormality and contained rupture; (4) rupture—presence of aortic external contour abnormality and free contrast extravasation or hemothorax at thoracotomy.

Results: We identified 140 patients with BAI. Most injuries were pseudoaneurysm (71%) at the isthmus (70%), 16.4% had an IT, 5.7% had a LIF, and 6.4% had a rupture. Survival rates by classification were IT, 87%; LIF, 100%; pseudoaneurysm, 76%; and rupture, 11% (one patient). Of the ITs, LIFs, and pseudoaneurysms treated nonoperatively, none worsened, and 65% completely healed. No patient with an IT or LIF died. Most patients with ruptures lost vital signs before presentation or in the emergency department and did not survive. Hypotension before or at hospital presentation and size of the periaortic hematoma at the level of the aortic arch predicted likelihood of death from BAI.

Conclusions: As a result of this new classification scheme, no patient without an external aortic contour abnormality died of their BAI. ITs can be managed nonoperatively. BAI patients with rupture will die, and resources could be prioritized elsewhere. Those with LIFs do well, and currently, most at our institution are treated with a stent graft. If a pseudoaneurysm is going to rupture, it does so early. Hematoma at the arch on computed tomography scan and hypotension before or at arrival help to predict which pseudoaneurysms need urgent repair. (J Vasc Surg 2012;55:47-54.)

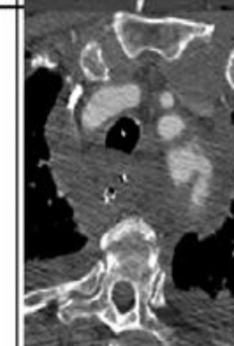
Absent External Contour Abnormality			Present External Contour Abnormality		
Type of Aortic Injury	*Definition*	*Example*	*Type of Aortic Injury*	*Definition*	*Example*
Intimal Tear	No aortic external contour abnormality: tear and/or associated thrombus is <10mm		**Pseudoaneurysm**	Aortic external contour abnormality: contained	
Large Intimal Flap	No aortic external contour abnormality: tear and/or associated thrombus is >10mm		**Rupture**	Aortic external contour abnormality: not contained, free rupture	

Fig 1. Blunt aortic injury classification scheme based on the presence or absence of aortic external contour abnormality on axial computed tomography imaging. Representative images are shown.

Original article

Grading system modification and management of blunt aortic injury

Kaavya N Reddy, Tim Matatov, Linda D Doucet, Maureen Heldmann, Cynthia X Zhao and Wayne W Zhang

Keywords: *blunt aortic injury; imaging grading system; endovascular management*

Background The traditional approach to blunt aortic injury (BAI) has been emergent intervention. This study aimed to utilize a modified imaging grading system that may allow us to categorize these injuries as needing emergent, urgent, or non-operative management.

Methods From January 2003 to December 2011, 28 patients with BAI were managed at our institution. Imaging and medical records were reviewed retrospectively. BAI was classified into 4 grades based on imaging studies. Grade Ia: intimal tear, Grade Ib: intramural hematoma; Grade II: intimal injury with periaotic hematoma; Grade IIIa: aortic transection with pseudoaneurysm, Grade IIIb: multiple aortic injuries; and Grade Ⅳ: free rupture. Progression and clinical outcomes of ABI were analyzed.

Results Of the 28 patients, 22 were males and 6 were females with mean age of 38 (range, 7–69) years. Twenty-five (89.3%) had descending thoracic aortic injury, two (7.1%) had abdominal aortic injury and one (3.6%) presented with multiple aortic injuries. Three patients (10.7%) with Grade I, 1 (3.6%) Grade II, 22 (78.6%) Grade III, and 2 (7.1%) Grade IV injuries. Twenty-five patients underwent thoracic endovascular aortic repair and 3 were managed medically. Median time between injury and surgical intervention was (2±1) days. One (3.6%) patient developed paraplegia after thoracic endovascular aortic repair (TEVAR). One Type 2 endoleak spontaneously sealed within 1 month, and another patient died from ruptured Type 1 endoleak 3 years later. Median follow-up time was 16 (range, 1–96) months. Perioperative 30-day mortality rate was 3.6%.

Conclusions This study based on our modified BAI grading system indicated that Grade I BAI can be managed conservatively. Grade II injury requires close observation and repeated computerized tomography angiogram (CTA) within 48–72 hours. If injury appears worse on follow up imaging, surgery should be performed. Delayed repair of Grade III BAI is acceptable if associated life threatening traumatic injuries need to be addressed first.

Chin Med J 2013;126 (3): 442-445

Table 1. Modified grading system of blunt aortic injury

Grade	Description	Patient population (%)
Ia	Intimal tear	10.7
Ib	Intramural hematoma	0
II	Intimal injury with periaortic hematoma	3.6
IIIa	Partial aortic transection with pseudoaneurysm	75
IIIb	Multiple aortic injuries	3.6
IV	Free rupture	6.4

64-year-old woman pedestrian hit by car with blunt thoracic aortic injury and closed pelvic fractures.

Natural history of grade I-II blunt traumatic aortic injury

Michael J. Osgood, MD,[a] Josh M. Heck, MD,[b] Eric J. Rellinger, MD,[a] Stacey L. Doran, MD,[a] C. Louis Garrard III, MD,[a] Raul J. Guzman, MD,[c] Thomas C. Naslund, MD,[a] and Jeffery B. Dattilo, MD,[a]
Nashville, Tenn; and Boston, Mass

Background: Endovascular aortic repair has revolutionized the management of traumatic blunt aortic injury (BAI). However, debate continues about the extent of injury requiring endovascular repair, particularly with regard to minimal aortic injury. Therefore, we conducted a retrospective observational analysis of our experience with these patients.
Methods: We retrospectively reviewed all BAI presenting to an academic level I trauma center over a 10-year period (2000-2010). Images were reviewed by a radiologist and graded according to Society for Vascular Surgery guidelines (grade I-IV). Demographics, injury severity, and outcomes were recorded.
Results: We identified 204 patients with BAI of the thoracic or abdominal aorta. Of these, 155 were deemed operative injuries at presentation, had grade III-IV injuries or aortic dissection, and were excluded from this analysis. The remaining 49 patients had 50 grade I-II injuries. We managed 46 grade I injuries (intimal tear or flap, 95%), and four grade II injuries (intramural hematoma, 5%) nonoperatively. Of these, 41 patients had follow-up imaging at a mean of 86 days postinjury and constitute our study cohort. Mean age was 41 years, and mean length of stay was 14 days. The majority (48 of 50, 96%) were thoracic aortic injuries and the remaining two (4%) were abdominal. On follow-up imaging, 23 of 43 (55%) had complete resolution of injury, 17 (40%) had no change in aortic injury, and two (5%) had progression of injury. Of the two patients with progression, one progressed from grade I to grade II and the other progressed from grade I to grade III (pseudoaneurysm). Mean time to progression was 16 days. Neither of the patients with injury progression required operative intervention or died during follow-up.
Conclusions: Injury progression in grade I-II BAI is rare (~5%) and did not cause death in our study cohort. Given that progression to grade III injury is possible, follow-up with repeat aortic imaging is reasonable. (J Vasc Surg 2014;59:334-42.)

Table I. Definitions used in this study regarding aortic injury grade and aortic injury evolution

Aortic injury grades	
Grade I aortic injury	aortic intimal tear or flap
Grade II aortic injury	aortic intramural hematoma without change in external contour of aorta
Grade III aortic injury	contained aortic pseudoaneurysm with concurrent increase in external contour of the aorta but without extravasation of intravenous contrast
Grade IV aortic injury	full-thickness aortic injury resulting in rupture with extravasation of intravenous contrast on imaging
Aortic injury evolution	
Injury resolution	interval injury resolution with aorta of normal diameter; absence of external contour abnormality or intraluminal filling defect; no identifiable aortic injury
Stable injury	no interval change in aortic injury
Injury progression	interval enlargement of injury, either by increase in injury grade, or by increase in size of injury with no change of injury grade

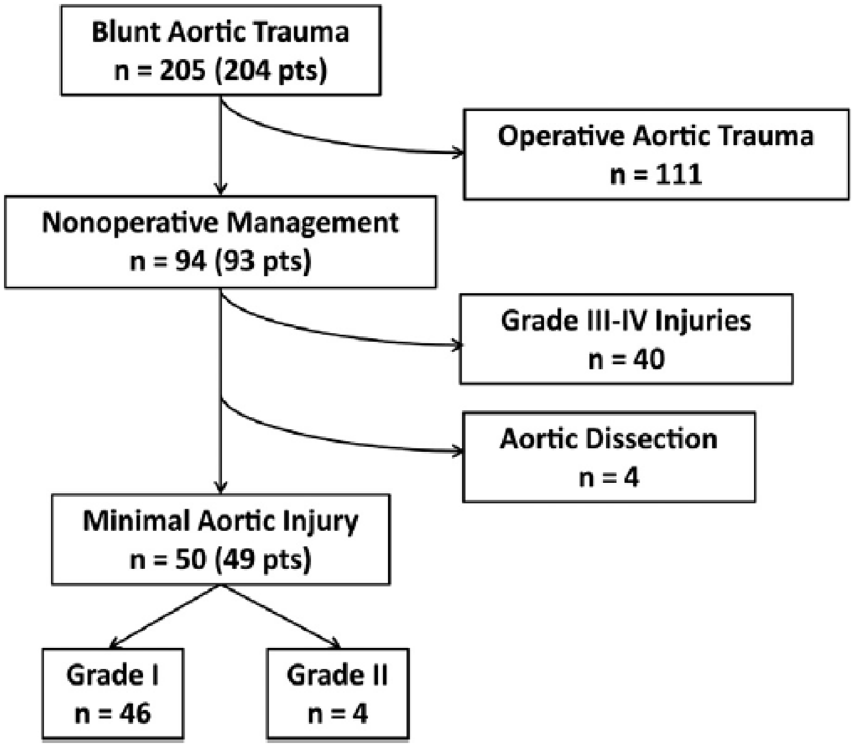


Fig 1. Diagram summarizing selection of patients for inclusion in this analysis. *pts,* Patients.

Natural history of grade I-II blunt traumatic aortic injury

Michael J. Osgood, MD,[a] Josh M. Heck, MD,[b] Eric J. Rellinger, MD,[a] Stacey L. Doran, MD,[a] C. Louis Garrard III, MD,[a] Raul J. Guzman, MD,[c] Thomas C. Naslund, MD,[a] and Jeffery B. Dattilo, MD,[a] *Nashville, Tenn; and Boston, Mass*

Background: Endovascular aortic repair has revolutionized the management of traumatic blunt aortic injury (BAI). However, debate continues about the extent of injury requiring endovascular repair, particularly with regard to minimal aortic injury. Therefore, we conducted a retrospective observational analysis of our experience with these patients.
Methods: We retrospectively reviewed all BAI presenting to an academic level I trauma center over a 10-year period (2000-2010). Images were reviewed by a radiologist and graded according to Society for Vascular Surgery guidelines (grade I-IV). Demographics, injury severity, and outcomes were recorded.
Results: We identified 204 patients with BAI of the thoracic or abdominal aorta. Of these, 155 were deemed operative injuries at presentation, had grade III-IV injuries or aortic dissection, and were excluded from this analysis. The remaining 49 patients had 50 grade I-II injuries. We managed 46 grade I injuries (intimal tear or flap, 95%), and four grade II injuries (intramural hematoma, 5%) nonoperatively. Of these, 41 patients had follow-up imaging at a mean of 86 days postinjury and constitute our study cohort. Mean age was 41 years, and mean length of stay was 14 days. The majority (48 of 50, 96%) were thoracic aortic injuries and the remaining two (4%) were abdominal. On follow-up imaging, 23 of 43 (55%) had complete resolution of injury, 17 (40%) had no change in aortic injury, and two (5%) had progression of injury. Of the two patients with progression, one progressed from grade I to grade II and the other progressed from grade I to grade III (pseudoaneurysm). Mean time to progression was 16 days. Neither of the patients with injury progression required operative intervention or died during follow-up.
Conclusions: Injury progression in grade I-II BAI is rare (~5%) and did not cause death in our study cohort. Given that progression to grade III injury is possible, follow-up with repeat aortic imaging is reasonable. (J Vasc Surg 2014;59:334-42.)

Table V. Summary of retrospective studies examining the natural history of blunt aortic injury (BAI)

Study	*Patients*	*Injury grade*	*Injury location*	*Imaging modality at diagnosis and follow-up*
Fabian et al (1998)[12]	n = 6	I (intimal flap with <10% lumen compromise)	Not specified	CTA, aortography
Malhotra et al (2001)[7]	n = 8	I (intimal tear <1 cm)	Thoracic aorta	CTA, aortography, IVUS
Kepros et al (2002)[10]	n = 5	I (intimal tears 5-20 mm)	Thoracic aorta	TEE
Holmes et al (2002)[15]	n = 6	I (intimal tear)	Thoracic aorta	CTA, aortography
	n = 2	II (intramural hematoma)	Thoracic aorta	CTA, aortography
Hirose et al (2006)[11]	n = 3	I (intimal tear)	Thoracic aorta	CTA, aortography
Azizzadeh et al (2009)[4]	n = 10	I (intimal tear)	Thoracic aorta	CTA, IVUS
Caffarelli et al (2010)[13]	n = 6	I (intraluminal thrombus/ intimal injury)	Thoracic aorta	CTA
	n = 2	II (intramural hematoma)	Thoracic aorta	CTA
Paul et al (2011)[6]	n = 11	I (intimal tear <1 cm)	Thoracic aorta	CTA
Mosquera et al (2012)[8]	n = 9	I (intimal tear <1 cm)	Thoracic and abdominal aorta	CTA, TEE, aortography
Starnes et al (2012)[9]	n = 20	I (intimal tear <1 cm)	Thoracic and abdominal aorta	CTA, TEE, aortography
	n = 2	I (intimal flap >1 cm)	Thoracic and abdominal aorta	CTA, TEE, aortography
Shalhub et al (2012)[14]	n = 6	I (intimal tear <1 cm)	Abdominal aorta	CTA
	n = 3	I (intimal flap >1 cm)	Abdominal aorta	CTA

CTA, Computed tomography angiography; *IVUS*, intravascular ultrasound; *MSOF*, multiple system organ failure; *TBI*, traumatic brain injury; *TEE*, trans-esophageal echocardiogram.

Table V. Continued.

Follow-up imaging	*Clinical follow-up*	*Aortic injury evolution among survivors*	*Aortic-related mortality*	*All-cause mortality*
Not specified	Not specified	Resolution in 5/6 (83%) Stable in 1/6 (17%)	0/6 (0%)	Not specified
<8 weeks	Not specified	Resolution in 2/6 (33%) Stable in 1/6 (17%) Progression to pseudoaneurysm in 3/6 (50%)	0/8 (0%)	2/8 (25%) -MSOF (n = 1) -PE (n =1)
9.4 days (mean)	16.8 months (mean)	Resolution in 5/5 (100%)	0/5 (0%)	0/5 (0%)
Not specified	2.5 years (median)	Resolution in 1/4 (25%) Stable in 3/4 (75%)	0/5 (0%)	1/5 (20%) -TBI
Not specified	2.5 years (median)	Resolution in 2/2 (50%)	0/2 (0%)	0/2 (0%)
60 days (median)	4.4 years (mean)	Resolution in 3/3 (50%)	0/3 (0%)	0/3 (0%)
None	Not specified	No follow-up imaging	0/10 (0%)	0/10 (0%)
81 days (mean) for entire cohort	1.8 years (median) for entire cohort	Resolution in 4/6 (66%) Stable in 2/6 (33%)	Not specified	Not specified
81 days (mean) for entire cohort	1.8 years (median) for entire cohort	Resolution in 1/2 (50%) Stable in 1/2 (50%)	Not specified	Not specified
4 days (median)	16 days (mean)	Not specified	0/11 (0%)	0/11 (0%)
Not specified	27 months (median)	Resolution in 6/7 (86%) Progression to pseudoaneurysm in 1/7 (14%)	0/9 (0%)	2/9 (22%) -MSOF (n = 1) -TBI (n = 1)
71 days (mean)	71 days	Resolution in 14/16 (87.5%) Stable in 2/16 (12.5%)	0/20 (0%)	3/20 (15%) -MSOF (n = 3)
7 days (mean)	7 days	Stable in 2/2 (100%)	0/2 (0%)	0/2 (0%)
<72 hours	6 days (median)	Resolution in 5/6 (83%) Stable in 1/6 (17%)	0/6 (0%)	0/6 (0%)
<72 hours	Not specified	Resolution in 1/3 (33%) Stable in 2/3 (66%)	0/3 (0%)	0/3 (0%)

Table IV. Characteristics of seven patients with grade I-II aortic injuries managed nonoperatively who died during follow-up

Patient	*Age, years*	*ISS*	*Aortic injury grade at presentation*	*Aortic injury grade on follow-up imaging*	*Last follow-up imaging, days postpresentation*	*Cause of death*	*Death, days postinjury*
1	19	29	I	Resolution (no sign of injury)	1	TBI	2
2	45	29	I	Resolution (no sign of injury)	131	Unknown	1043
3	46	32	I	I (no change in injury)	3	MSOF	4
4	31	36	I	I (no change in injury)	2	MSOF	13
5	87	50	I	I (no change in injury)	8	MSOF	9
6	50	45	I	Not performed	–	TBI	1
7	81	21	II	Not performed	–	MSOF	6

ISS, Injury Severity Score; *MSOF*, multiple system organ failure; *TBI*, traumatic brain injury.

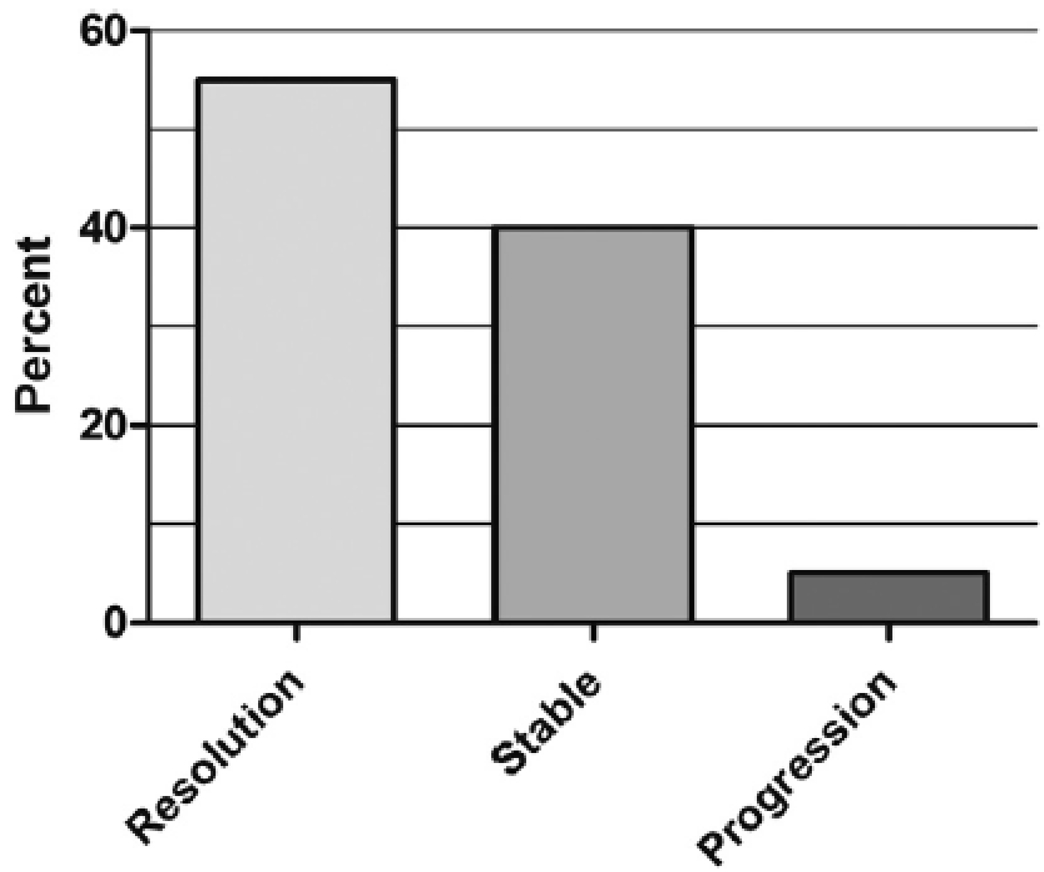


Fig 2. Evolution of injury following grade I-II blunt aortic injury (BAI). Between the time of injury and last follow-up imaging, 55% of patients demonstrated complete injury resolution, 40% had stable injuries, and 5% of patients developed injury progression to higher injury grade.

TRAUMATIC AORTIC INJURY

Surgical Management

Fabian, J Trauma; 1997:374-383

Prospective trial involving 50 trauma centers in the U.S. over 2.5 years

- 274 cases of blunt aortic injury
- 204 underwent thoracotomy with open repair

- Post-operative MORTALITY: 14%
- Post-operative PARAPLEGIA: 8.7%

Traumatic Aortic Transection

Open results	Clamp and Sew		Distal Perfusion	
	Paraplegia	Mortality	Paraplegia	Mortality
Von Oppell (94) 87 studies 1492 pts	19.0%	16.0%	6.1%	15.0%
Kadali (1991)	28.5%		3.8%	

J Vasc Surg 2006: 43 (2): A22-A29

Open Surgery vs Endografts

Open Repair vs Endografts

The Higher the Mortality and Morbidity of Open Repair for any pathology, The more obvious the benefit of alternative Endovascular Intervention.

How about Aortic Transection?

Noriyuki Kato, MD • Michael D. Dake, MD • D. Craig Miller, MD • Charles P. Semba, MD
R. Scott Mitchell, MD • Mahmood K. Razavi, MD • Stephen T. Kee, MD

Traumatic Thoracic Aortic Aneurysm: Treatment with Endovascular Stent-Grafts[1]

RESULTS: **Stent-graft placement and thrombosis of the aneurysmal sac were successful in all patients. Major complications were encountered in three patients after endovascular treatment. One patient had a perigraft leak; complete thrombosis of the aneurysmal sac was achieved after coil embolization of the leak. Transposition of the left subclavian artery was necessary to relieve left arm ischemia in another patient. In the third patient, stent placement in the left main stem bronchus was needed to relieve left lung atelectasis. All patients were alive and without complications during the follow-up period (mean, 15 months).**

CONCLUSION: **Transluminal placement of endovascular stent-grafts is a technically feasible method for treatment of traumatic thoracic aortic aneurysm and may be an effective alternative to open-chest surgery.**

attendant risk of fatal rupture (5,6). Traditionally, chronic traumatic aortic aneurysms are also surgically repaired, although the operation is associated with many major and minor complications (7). Since Parodi et al (8) described their first clinical experience with the use of a stent-graft to treat an abdominal aortic aneurysm, endoluminal stent-graft placement is emerging as an alternative to traditional surgery when patients with aneurysmal or occlusive disease have important coexistent morbidities (8–17). There is still controversy about how to manage both acute and chronic aortic injuries (1–6). We describe our experience using endoluminal placement of stent-grafts to treat traumatic descending thoracic aortic aneurysm in 10 cases. The purpose of our study was to demonstrate the feasibility and safety of the endoluminal treatment in patients with a thoracic aortic aneurysm.

Index terms: Aneurysm, aortic, 563.732 • Aorta, cedure, 563.1269

Radiology 1997; 205:657–662

Traumatic Aortic Transection

Endovascular management of traumatic ruptures of the thoracic aorta: A retrospective multicenter analysis of 28 cases in The Netherlands

Liselot L. Hoornweg, MD,[a] Maarten K. Dinkelman, MD,[b] J. Carel Goslings, MD, PhD,[c] Jim A. Reekers, MD, PhD,[d] Hence J. M. Verhagen, MD, PhD,[b] Eric L. Verhoeven, MD, PhD,[e] Geert Willem H. Schurink, MD, PhD,[f] and Ron Balm, MD, PhD,[a] *Amsterdam, Utrecht, Groningen, and Maastricht, The Netherlands*

Background: Minimally invasive endovascular treatment of a traumatic rupture of the thoracic aorta is a new strategy in the care of multitrauma patients. We report the experience in The Netherlands with endovascular management of patients with acute traumatic ruptures of the thoracic aorta.
Methods: We reviewed 28 patients with a traumatic thoracic aortic rupture treated with a thoracic aortic endograft between June 2000 and April 2004. All patients underwent treatment at one of the four participating level 1 trauma centers. Data collected included age, sex, injury severity score, type of endovascular graft, endovascular operation time, length of stay, length of stay in the intensive care unit, and mortality. Follow-up data consisted of computed tomographic angiography and plain chest radiographs at regular intervals.
Results: All patients (mean age, 40.9 years; SD, 18.5 years) experienced severe traumatic injury, and the mean injury severity score was 37.1 (SD, 7.8). All endovascular procedures were technically successful, and the median operating time for the endovascular procedure was 58 minutes (interquartile range, 47-88 minutes). The overall hospital mortality was 14.3% (n = 4), and all deaths were unrelated to the aortic rupture or stent placement. There was no intervention-related mortality during a median follow-up of 26.5 months (interquartile range, 10-34.6 months). Postoperative data showed no severe endovascular graft- or procedure-related morbidity, except for one patient with an asymptomatic collapse of the endovascular graft during regular follow-up. This was corrected by placing a second graft.
Conclusions: This study shows that the results of immediate endovascular repair of a traumatic aortic rupture are at least equal to those of conventional open surgical repair. Especially in these multitrauma patients with traumatic ruptures of the thoracic aorta, endovascular therapy seems to be preferable to conventional open surgical repair. (J Vasc Surg 2006;43:1096-102.)

- **2000-04**
- **28 pts**
- **Injury score 37.1**
- **OR time 58 min**
- **Mortality 0%**
- **Paraplegia 0%**
- **1 graft collapse**

Rx with 2nd graft

J Vasc Surg 2006;43:1096-102

Traumatic Aortic Transection

Blunt thoracic aortic injury: A single institution comparison of open and endovascular management

Peter I. Midgley, MD, Kent S. MacKenzie, MD, Marc M. Corriveau, MD, Daniel I. Obrand, MD, Cherrie Z. Abraham, MD, Paola Fata, MD, and Oren K. Steinmetz, MD, *Montreal, Quebec, Canada*

Objective: To review the treatment of blunt thoracic aortic injuries (BAI) at a single institution over the past 12 years and compare pre-, peri-, and postoperative variables and outcomes of both open (OR) and thoracic endovascular (TEVAR) repair of these injuries.
Methods: All cases of confirmed BAI from 1994 to present were included in this retrospective review. Data collected included demographic data, injury severity score, Glasgow coma score, arrival hemodynamic variables, and associated injuries. Operative data included: type of procedure (OR or TEVAR), duration of procedure, need for and amount of blood transfused, use of anticoagulation, type of anesthesia, and service performing the procedure. Outcomes evaluated were: death, paraplegia, length of stay, days ventilated, and procedure related complications. Specific to EVAR; access, stent graft type and number, presence of endoleak and long-term clinical and radiologic follow-up were evaluated.
Results: Thirty cases of blunt thoracic aortic injury were identified. Two patients received no treatment and died, 28 patients were treated (OR 16, TEVAR 12) and included for comparison. There were no significant differences between groups with respect to preoperative variables with the exception of significantly more associated intra-abdominal injuries

J Vasc Surg 2007; 46:662-668

Traumatic Aortic Transection

Endo vs Open at One Institution

- 1994-2006 - 30 patients – 2 no RX
- 16 open Repair
  - 5 deaths
  - 1 paraplegia
  - Blood Transfused 8.2 units
- 12 TEVAR
  - No deaths
  - No paraplegia
  - Blood Transfused 0.2 units

Mortality 31%
Paraplegia 6.2%

Mortality 0%
Paraplegia 0%

J Vasc Surg 2007; 46:662-668

Traumatic Aortic Transection

Thoracic endovascular aortic repair for traumatic aortic transection

Michael R. Go, MD, Joel E. Barbato, MD, Ellen D. Dillavoum, MD, Navyash Gupta, MD, Robert Y. Rhee, MD, Michel S. Makaroun, MD, and Jae-Sung Cho, MD, *Pittsburgh, Pa*

Background: Traumatic transection of the thoracic aorta is a highly morbid injury. Treatment may be delayed while attention focuses on concomitant injuries. Thoracic endovascular aortic repair (TEVAR) is effective but remains controversial in these often-young patients. We reviewed our experience in acute and subacute treatment of these injuries with TEVAR.
Methods: A retrospective analysis of five men and five women who underwent TEVAR for aortic transection from 1999 to 2007 was conducted. Procedures were performed with standard endovascular techniques. Follow-up included computed tomography at 1 month and yearly thereafter.
Results: Mean age was 44 years (range, 20 to 84 years). Motor vehicle accidents accounted for 7 injuries, a snowmobile accident for 1, skydiving for 1, and balloon angioplasty of a coarctation for 1. Average diameter of the proximal landing

J Vasc Surg 2007; 46:928-33

Traumatic Aortic Transection

Endo vs Open at UPMC 1999-2008

- 45 open Repairs
  - 9 deaths — Mortality 19%
  - Last case Jan 2007: 18year old with isolated injury
    8 hour procedure, massive bleeding paraplegia and Death
- 23 TEVAR / 19 Acute: 4 abdominal cuffs/ 2 TX2/ 13 TAG
  - No deaths — Mortality 0%
  - No paraplegia — Paraplegia 0%
  - Since Feb 2007 11 acute Transections All Rx by TEVAR

J Vasc Surg 2007;46:928-33

Endovascular Repair in Traumatic Thoracic Aortic Injuries: Comparison with Open Surgical Repair

John Chung, BSc, Richard Owen, MBBCh, Robert Turnbull, MD, Harold Chyczij, MD, Gerrit Winkelaar, MD, and Noel Gibney, MBBCh

PURPOSE: Thoracic endovascular aortic repair (TEVAR) has emerged as an alternative to open surgical repair (OSR) of traumatic thoracic aortic injury (TTAI). Herein immediate and midterm outcomes of TEVAR are compared with those of OSR.

MATERIALS AND METHODS: Health records were used to identify patients with TTAI presenting between April 1995 and September 2006. Preoperative patient characteristics, intraoperative variables, procedural costs, and outcomes were recorded.

RESULTS: A total of 103 patients were identified. Twenty-two died before treatment, 19 were treated conservatively, 36 received OSR, and 26 received TEVAR. In the OSR group, time from diagnosis to treatment was 8 hours, the 30-day mortality rate was 11.1%, and all deaths occurred intraoperatively. Thoracic nerve injury occurred in four patients (12.5%), pneumonia in 12 (37.5%), temporary renal failure in one (3%), paraparesis in three (9.4%), and paraplegia in five (15.6%). On follow-up (mean, 61 months), postthoracotomy pleural reaction was seen in three cases (9.4%). In the TEVAR group, time to treatment was 38 hours ($P < .01$) and the 30-day mortality rate was 7.4% with no intraoperative deaths. Pneumonia was seen in two cases (8.3%) and left arm ischemia was seen in two of 17 patients in whom the left

J Vasc Interv Radiol 2008 ; 19:478-486

Traumatic Aortic Transection

Endo vs Open at One Institution

- 1995-2006 - 103 patients – 22 died before Rx; 19 no Rx
- 36 open Repair
  - 4 deaths (all intra op) @ 30d
  - 8 paraplegia
  - 15 clamp and sew; 17 LH bypass
- 26 TEVAR
  - 2 deaths (intra op) @ 30d
  - No paraplegia
  - No repeat interventions @ 1 yr

Mortality 11.1%
Paraplegia 25%

Mortality 7.4%
Paraplegia 0%

JVIR 2008; 19:479-486

Traumatic Aortic Transection

Endovascular treatment of traumatic thoracic aortic injury—should this be the new standard of treatment?

Peter H. Lin, MD, Ruth L. Bush, MD, Wei Zhou, MD, Eric K. Peden, MD, and **Alan B. Lumsden, MD,** *Houston, Texas*

INTRODUCTION

Blunt trauma to the thoracic aorta is a potentially life-threatening condition that can lead to death in 75% of cases at the time of injury, as a result of either aortic transection or acute rupture.[1] Although it accounts for <1% of adult admissions to level I trauma centers, blunt aortic injury represents the second most common cause of death due to blunt trauma, second to head injury.[2] It is estimated that only 25% of patients who sustain aortic injuries due to blunt thoracic trauma remain alive upon arrival to the hospital. The prognosis for patients who

other organs that can not only compound therapeutic challenges in their surgical management but also increase their overall morbidity and mortality.

The objectives of this chapter are to review current treatment strategies of blunt aortic injury, including both conventional open repair and endovascular treatment approach. Further discussions are provided on technical maneuvers to facilitate endovascular treatment, potential limitations of endovascular therapy, and clinical results of this treatment modality in blunt aortic injury.

J Vasc Surg 2006: 43 (2): A22-A29

Traumatic Aortic Transection

Endo Results 17 Reports

Author	Year	Patients	Technical Success (%)	Endograft type	Mortality	Paraplegia	Follow-up (months)
Bortone	2002	10	100%	Gore	NA	None	14
Orend	2002	11	92%	Gore, Talent	NA	None	14
Thompson	2002	5	100%	Gore, custom	0	None	20
Fattori	2002	11	100%	Gore, Talent	0	None	20
Lachat	2002	12	100%	Gore, Talent	1	None	9
Kasirajan	2003	5	100%	Gore, Talent, homemade	0	None	10
Karmy-Jones	2003	11	100%	AneuRx cuff, Ancure, Talent, homemade	NA	None	16
Iannelli	2004	3	100%	Gore	NA	None	13
Wellons	2004	9	100%	AneuRx cuff, Excluder cuff	0	None	6
Kato	2004	6	100%	Homemade	NA	None	6
Scheinert	2004	10	100%	Gore, Talent	NA	None	17
Czermak	2004	12	92%	Gore, Talent	NA	None	9
Morishita	2004	7	100%	Homemade	NA	None	12
Neuhauser	2004	10	100%	Gore, Talent, Vanguard	NA	None	26
Ott	2004	6	100%	Talent	0	None	16
Uzieblo	2004	4	100%	Talent	NA	None	8
Bortone	2004	14	100%	Talent, Gore, Zenith, Endofit	NA	None	14
Total		146	**99%**		**1 of 48 (2%)**	**None**	

	Patients	Technical Success	Mortality	Paraplegia
Total	**146**	**99%**	**2%**	**0**

J Vasc Surg 2006: 43 (2): A22-A29

Traumatic Aortic Transection

Endovascular repair of traumatic rupture of the aortic isthmus: Midterm results

Bertrand Marcheix, MD,[a] Camille Dambrin, MD, PhD,[a] Jean-Philippe Bolduc, MD,[b] Catherine Arnaud, MD,[c] Lucy Hollington, MD,[d] Christophe Cron, MD,[a] Antoine Mugniot, MD,[a] Philippe Soula, MD,[a] Mehdi Bennaceur, MD,[b] Valérie Chabbert, MD,[b] Philippe Otal, MD,[b] Alain Cérène, MD,[a] and Hervé Rousseau, MD, PhD[b]

Objective: The endovascular management of aortic traumatic ruptures has been proposed as an alternative to classical surgical procedures. The aim of this work was to report the midterm results of the endovascular treatment of traumatic ruptures of the isthmic aorta.

Methods: Between January 1996 and July 2005, endovascular repair of blunt traumatic aortic ruptures was performed in 33 patients (mean age, 40 ± 17 years).

J Thor Cardiovasc Surg 2006: 132 (5): 1037

Endovascular Repair of Aortic Transection

- **33 patients from 1996 to 2005 (<u>Subacute Setting</u>)**
- **Talent 27 TAG 4 Vanguard 2 All successful**
- **One iliac rupture**
- **Mortality 0%**
- **Paraplegia 0% One transient paraperesis**
- **<u>No Conversions, No Reinterventions</u>**
- **96% freedom from complication @ 1 year**
- **No significant complication in FU**

J Thor Cardiovasc Surg 2006: 132 (5): 1037

CAUTION: investigational off label use

From the Southern Association for Vascular Surgery

Meta-analysis of endovascular vs open repair for traumatic descending thoracic aortic rupture

Eleftherios S. Xenos, MD, PhD, Nicholas N. Abedi, MD, Daniel L. Davenport, PhD, David J. Minion, MD, Omar Hamdallah, MD, Ehab E. Sorial, MD, and Eric D. Endean, MD, *Lexington, Ky*

Objectives: Traumatic thoracic aortic injuries are associated with high mortality and morbidity. These patients often have multiple injuries, and delayed aortic repair is frequently used. Endoluminal grafts offer an alternative to open surgical repair. We performed a meta-analysis of comparative studies evaluating endovascular vs open repair of these injuries.
Methods: A systematic search of studies reporting treatment of traumatic aortic injury was performed using the following databases: Medline/PubMed, CINAHL, Proquest, Up to Date, Database of Abstracts of Reviews of Effects (DARE), ClinicalTrials.gov, the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews. Search terms were thoracic aortic trauma, traumatic thoracic aortic injury, traumatic aortic rupture, stent graft repair, and endovascular repair. Outcomes analyzed were procedure-related mortality, overall 30-day mortality, and paraplegia/paraparesis rate using odds ratios (OR) and 95% confidence intervals (CI). Publication bias was investigated using funnel plots. Assessment of homogeneity was performed using the Q test; statistical heterogeneity was considered present at $P < .05$. Weighted averages of age, interval to repair, and injury severity score were compared with the Welch *t* test; $P < .05$ was considered statistically significant.
Results: Seventeen retrospective cohort studies from 2003 to 2007 were included. All were nonrandomized; no prospective randomized trials were found. These studies reported on 589 patients; 369 were treated with open repair, and 220 underwent thoracic stent graft placement. There was no significant difference in age (mean 38.8 years for both) or interval to repair (mean 1.5 days for endoluminal repair; 1 day for open repair). Injury severity score was higher for patients undergoing endoluminal repair (mean, 42.4 vs 37.4 for open repair, $P < .001$). Procedure-related mortality was significantly lower with endoluminal repair (OR, 0.31; 95% CI, 0.15-0.66; $P = .002$). Overall 30-day mortality was also lower after endoluminal repair (OR, 0.44; 95% CI, 0.25-0.78; $P = .005$). Sixteen studies reported data for postoperative paraplegia; 215 patients were treated with endograft placement and 333 with open repair. The risk of postoperative paraplegia was significantly less with endoluminal repair (OR, 0.32; 95% CI, 0.1-0.93; $P = .037$). The Q test did not indicate significant heterogeneity for the outcomes of interest; publication bias was limited.
Conclusions: Meta-analysis of retrospective cohort studies indicates that endovascular treatment of descending thoracic aortic trauma is an alternative to open repair and is associated with lower postoperative mortality and ischemic spinal cord complication rates. (J Vasc Surg 2008;48:1343-51.)

Procedure-related Mortality

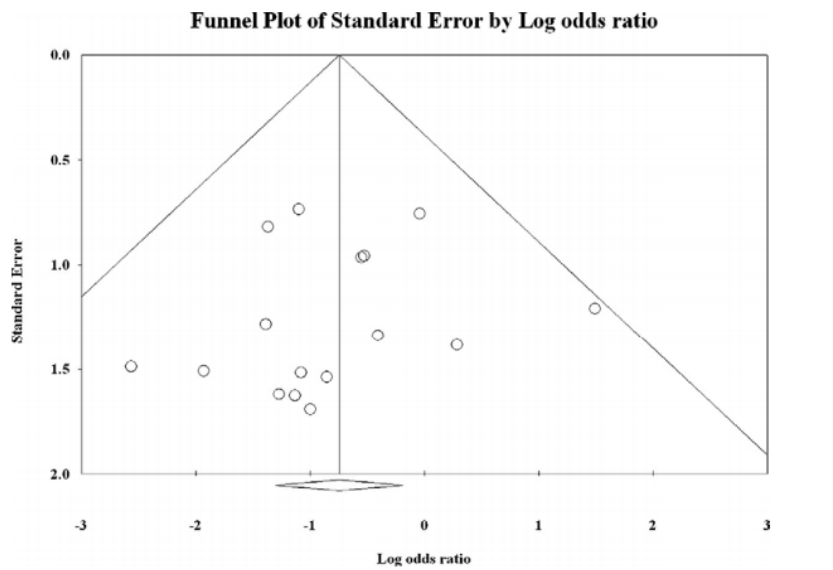


Fig 1. Study results demonstrate an overall inverted funnel shape indicating minimal publication bias.

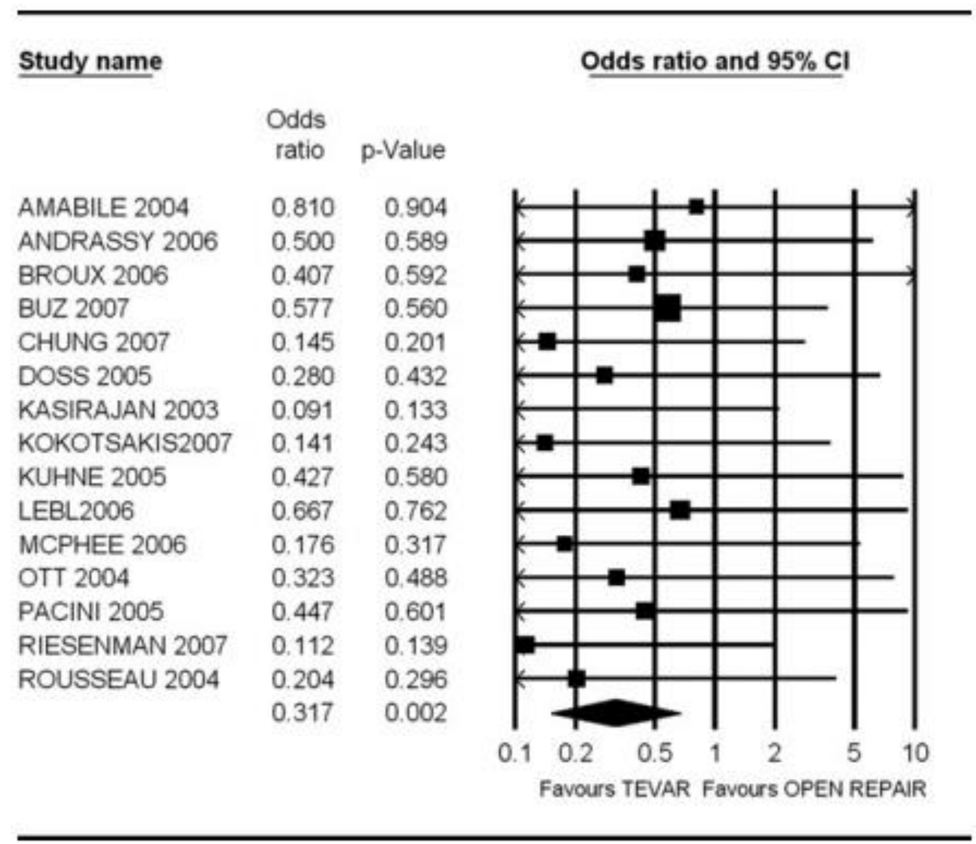


Fig 2. Forest plot shows procedure-related mortality *(PRM)* in thoracic endovascular aneurysm repair (*TEVAR*) vs open repair of traumatic descending aortic rupture. *CI*, Confidence interval.

Table III. Outcomes from 17 studies of endovascular versus open repair of traumatic descending thoracic aortic Rupture

	Patients, No. (%)			*Procedure-related mortality, No. (%)*		*30-day mortality, No. (%)*		*Paraplegia/paresis, No. (%)*	
First author (year)	*Total*	*TEVAR*	*Open*	*TEVAR*	*Open*	*TEVAR*	*Open*	*TEVAR*	*Open*
Amabile (2004)	12	3 (25)	9 (75)	0 (0)	1 (11)	0 (0)	1 (11)	0 (0)	0 (0)
Andrassy (2006)	31	15 (48)	16 (52)	1 (7)	2 (13)	2 (13)	3 (19)	0 (0)	2 (13)
Broux (2006)	30	13 (43)	17 (57)	0 (0)	1 (6)	2 (15)	4 (24)	0 (0)	1 (6)
Buz (2007)	74	39 (53)	35 (47)	2 (5)	3 (9)	3 (8)	7 (20)	0 (0)	0 (0)
Chung (2007)	71	29 (41)	42 (59)	0 (0)	4 (10)	0 (0)	4 (10)	0 (0)	8 (19)
Cook (2006)	42	19 (45)	23 (55)	0 (0)	0 (0)	4 (21)	5 (22)	0 (0)	1 (4)
Doss (2005)	19	7 (37)	12 (63)	0 (0)	2 (17)	0 (0)	2 (17)	1 (14)	0 (0)
Kasirajan (2003)	15	5 (33)	10 (67)	0 (0)	5 (50)	1 (20)	5 (50)	0 (0)	0 (0)
Kokotsakis (2007)	32	22 (69)	10 (31)	0 (0)	1 (10)	1 (5)	1 (10)	0 (0)	1 (10)
Kuhne (2005)	41	5 (12)	36 (88)	0 (0)	6 (17)	0 (0)	6 (17)	N/S	N/S
Lebl (2006)	17	7 (41)	10 (59)	1 (14)	2 (20)	1 (14)	2 (20)	0 (0)	0 (0)
Mcphee (2006)	13	8 (62)	5 (38)	0 (0)	1 (20)	2 (25)	1 (20)	0 (0)	0 (0)
Ott (2004)	18	6 (33)	12 (67)	0 (0)	2 (17)	0 (0)	2 (17)	0 (0)	2 (17)
Pacini (2005)	66	15 (23)	51 (77)	0 (0)	3 (6)	0 (0)	4 (8)	0 (0)	4 (8)
Riesenman (2007)	62	14 (23)	48 (77)	0 (0)	11 (23)	2 (14)	19 (40)	0 (0)	0 (0)
Rousseau (2004)	36	8 (22)	28 (78)	0 (0)	6 (21)	0 (0)	6 (21)	0 (0)	3 (11)
Stampfl (2005)	10	5 (50)	5 (50)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	589	220 (37)	369 (63)	4 (2)	50 (14)	18 (8)	72 (20)	1 (0)[a]	22 (7)[a]

N/S, Indicates outcome not studied; *TEVAR*, thoracic endovascular aneurysm repair.
[a]Total sample is less due to Kuhne (2005) not including this outcome.

30-day Mortality and Neurologic Injury

Study name	Odds ratio	p-Value
AMABILE 2004	0.810	0.904
ANDRASSY 2006	0.667	0.683
BROUX 2006	0.591	0.583
BUZ 2007	0.333	0.135
CHUNG 2007	0.145	0.201
COOK 2006	0.960	0.957
DOSS 2005	0.280	0.432
KASIRAJAN 2003	0.250	0.280
KOKOTSAKIS2007	0.429	0.564
KUHNE 2005	0.427	0.580
LEBL2006	0.667	0.762
MCPHEE 2006	1.333	0.835
OTT 2004	0.323	0.488
PACINI 2005	0.341	0.478
RIESENMAN 2007	0.254	0.095
ROUSSEAU 2004	0.204	0.296
	0.447	0.005

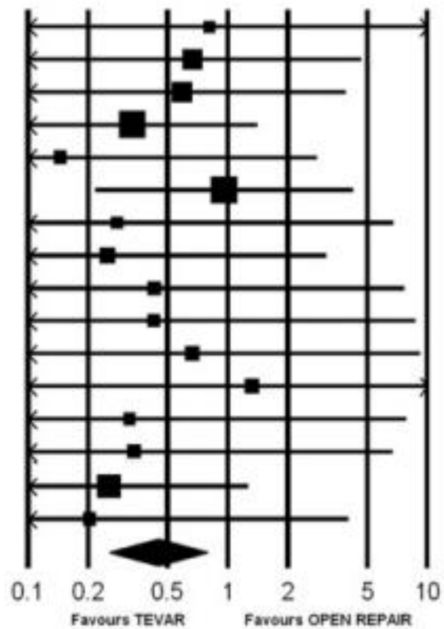


Fig 3. Forest plot shows 30-day mortality in thoracic endovascular aneurysm repair *(TEVAR)* vs open repair of traumatic descending aortic rupture.

Study name	Odds ratio	p-Value
ANDRASSY 2006	0.187	0.292
BROUX 2006	0.407	0.592
CHUNG 2007	0.069	0.070
COOK 2006	0.385	0.565
DOSS 2005	5.769	0.303
KOKOTSAKIS2007	0.141	0.243
OTT 2004	0.323	0.488
PACINI 2005	0.341	0.478
ROUSSEAU 2005	0.429	0.588
	0.328	0.037

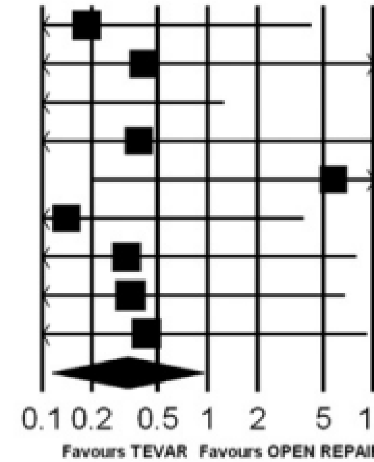


Fig 4. Forest plot shows paraplegia/paraparesis in thoracic endovascular aneurysm repair *(TEVAR)* vs open repair of traumatic descending aortic rupture.

Reduced mortality, paraplegia, and stroke with stent graft repair of blunt aortic transections: A modern meta-analysis

Gale L. Tang, MD,[a] Hassan Y. Tehrani, MD, ChB,[b] Asad Usman, BS,[a] Kushagra Katariya, MD,[b] Chris Otero, MD,[c] Eduardo Perez, MD,[c] and Mark K. Eskandari, MD,[a] *Chicago, Ill; Gurgaon, Haryana, India; and Miami, Fla*

Objective: Stent grafting has become the first-line approach to traumatic thoracic aortic transections (TTAT) in some trauma centers due to a perceived decrease in morbidity and mortality compared with standard open repair. We reviewed contemporary outcomes of patients undergoing endovascular repair of TTAT (endoTTAT) and those undergoing open repair (openTTAT) to determine if current reported results support first-line use of endoTTAT.
Method: Retrospective, nonrandomized studies published in English (>5 cases/report) involving TTAT listed in PubMed between 2001 and 2006 were systematically reviewed. Periprocedural outcomes between endoTTAT and openTTAT were analyzed. Mean follow-up was 22.9 months for endoTTAT (reported for 22 of 28 studies) and 48.6 months for openTTAT (reported for 5 of 12 studies). For statistical analysis, *t* tests were used.
Results: We analyzed 33 articles reporting 699 procedures in which 370 patients treated with endoTTAT and 329 patients managed with openTTAT. No statistical differences were found between patient groups in mean age (41.3 vs 38.8 years, $P < .10$), injury severity score (39.8 vs 36.0, $P < .10$), or technical success rates of the procedure (96.5% vs 98.5%, $P = .58$). In contrast, mortality was significantly lower in the endoTTAT group (7.6% vs 15.2%, $P = .0076$) as were rates of paraplegia (0% vs 5.6%, $P < .0001$) and stroke (0.85% vs 5.3%, $P = .0028$). The most common procedure-related complications for each technique were iliac artery injury during endoTTAT and recurrent laryngeal nerve injury after openTTAT.
Conclusions: To our knowledge, no large multicenter prospective randomized trial comparing endoTTAT and openTTAT has been published in the literature. This meta-analysis of pooled data serves as a surrogate, demonstrating a significant reduction in mortality, paraplegia, and stroke rates in patients who undergo endoTTAT; however, the long-term durability of endoTTAT remains in question. (J Vasc Surg 2008;47:671-5.)

Evolution of treatment for traumatic thoracic aortic injuries

Rolando I. Celis, MD,[a] Sun C. Park, MD,[a] Ankur J. Shukla, MD,[a] Mazen S. Zenati, MD,[b] Rabih A. Chaer, MD,[a] Robert Y. Rhee, MD,[a] Michel S. Makaroun, MD,[a] and Jae-Sung Cho, MD,[a] *Pittsburgh, Pa*

Objective: To review the evolution of traumatic thoracic aortic injury (TTAI) treatment at a single institution.
Methods: Retrospective analysis of all patients included in an institutional trauma registry and vascular surgery database who underwent treatment of TTAI between January 1999 and January 2011.
Results: Ninety-one patients (69 males) were treated for TTAI. The mean age was 38.5 years (range, 16-79 years). Forty-one patients underwent open repair (OR) and 50 thoracic endovascular repair (TEVAR), 37 with thoracic stent grafts (TSG) alone, 11 with infrarenal aortic extender cuffs (AEC), and two with a combination of TSG and AEC. OR was performed exclusively until 2004; the last one was performed in January 2007. All TTAIs have since been treated with TEVAR. The left subclavian artery (LSA) was fully covered in 10 patients (20%) and partially covered in eight patients, with revascularization in only two cases. The use of AEC and avoidance of LSA coverage increased after 2007. Baseline characteristics and injury severity scores were similar between groups. The mortality rate was higher in the OR group (19.5% vs 6.0%; $P = .06$), although it did not reach statistical significance. The overall incidence of morbidities was similar between the two groups (42% OR vs 50% TEVAR). Two patients developed paraplegia (4.4%) after OR compared with none after TEVAR. In the TEVAR group, a pseudoaneurysm, an iliac artery thrombosis, and a retroperitoneal hematoma developed in one patient each. Overall, eight patients (16%) developed stent graft-related complications (SRC), with two developing early (within 30 days) complications. All complications were related to poor apposition, requiring 10 reinterventions. Four patients underwent open conversions with no mortality. Nine out of 10 SRCs were associated with the use of thoracic stent graft malapposition. No patient treated with AEC had endoleaks or SRC.
Conclusions: TEVAR for TTAI has superior survival outcomes and has replaced OR. SRC requiring reintervention is associated with malapposition and the use of TSG. Until TTAI-specific endografts become available, use of AEC may minimize malapposition and reduce reinterventions. Routine overstenting of the LSA is not necessary and may increase SRC. (J Vasc Surg 2012;56:74-80.)

Acute blunt traumatic injury to the descending thoracic aorta

Paul J. Riesenman, MD, MS, James D. Brooks, BS, and **Mark A. Farber, MD,** *Chapel Hill, NC*

Introduction: Blunt injury to the descending thoracic aorta is a potentially life-threatening condition necessitating rapid assessment and possible surgical intervention. The purpose of this study was to review outcomes of patients who sustained blunt thoracic aortic injury at a single institution.
Methods: Our institutional Trauma Registry Database was searched for patients who sustained acute blunt descending thoracic aortic injury between July 1990 and July 2010. Individual injuries, anatomic and physiological measures of injury severity, and operative and hospital mortality were compared between patients undergoing open surgical and thoracic endovascular aortic repair. Additionally, aortic injury grade, management, and outcomes were reviewed for patients who did not undergo an aortic intervention.
Results: Of the 100 patients identified over the 20-year study period, 60 (60%) underwent conventional open repair, 26 (26%) underwent endovascular repair, and 14 (14%) did not undergo an aortic intervention. The overall hospital mortality rate for the entire patient cohort was 34%. Of the 14 patients who did not undergo an aortic intervention, five (36%) were successfully medically managed and four (80%) of these had grade I aortic injuries. One of the successfully medically managed patients required endovascular repair 9 months after injury. Four medically managed patients expired as a result of aortic rupture within 1 to 2.5 hours of presentation. Two expired immediately after diagnosis, and the other two could have potentially been treated with improvements in transfer and diagnosis times. Age, individual injuries, and measures of injury severity were similar between patients undergoing open surgical or endovascular repair. Patients who underwent endovascular repair experienced a significantly lower intraoperative (0% vs 18%; $P < .05$) and overall hospital mortality (12% vs 37%; $P < .05$). Additionally, endovascular repair was associated with reductions in operative time, estimated blood loss, and intraoperative blood transfusions. Five endovascular patients required secondary interventions to treat endograft-related complications, including malapposition to the aortic arch (n = 3), midendograft stenosis (n = 1), and left upper extremity ischemia (n = 1).
Conclusions: Blunt thoracic aortic injury to the descending thoracic aorta is associated with a high overall hospital mortality. Thoracic endovascular aortic repair is associated with significantly lower operative times, procedural blood loss, intraoperative blood transfusion, as well as intraoperative and overall hospital mortality compared with conventional open surgical repair. Consideration of this form of therapy as the initial form of treatment is warranted in anatomically acceptable candidates. (J Vasc Surg 2012;56:1274-80.)

The Journal of TRAUMA® Injury, Infection, and Critical Care

Operative Repair or Endovascular Stent Graft in Blunt Traumatic Thoracic Aortic Injuries: Results of an American Association for the Surgery of Trauma Multicenter Study

Demetrios Demetriades, MD, PhD, FACS, George C. Velmahos, MD, Thomas M. Scalea, MD, Gregory J. Jurkovich, MD, Riyad Karmy-Jones, MD, Pedro G. Teixeira, MD, Mark R. Hemmila, MD, James V. O'Connor, MD, Mark O. McKenney, MD, Forrest O. Moore, MD, Jason London, MD, Michael J. Singh, MD, Edward Lineen, MD, Konstantinos Spaniolas, MD, Marius Keel, MD, Michael Sugrue, MD, Wendy L. Wahl, MD, Jonathan Hill, MD, Mathew J. Wall, MD, Ernest E. Moore, MD, Daniel Margulies, MD, Valerie Malka, MD, and Linda S. Chan, PhD

Introduction: The purpose of this American Association for the Surgery of Trauma multicenter study is to assess the early efficacy and safety of endovascular stent grafts (SGs) in traumatic thoracic aortic injuries and compare outcomes with the standard operative repair (OR).

Patients: Prospective, multicenter study. Data for the following were collected: age, blood pressure, and Glasgow Coma Scale (GCS) at admission, type of aortic injury, injury severity score, abbreviate injury scale (AIS), transfusions, survival, ventilator days, complications, and intensive care unit and hospital days. The outcomes between the two groups (open repair or SG) were compared, adjusting for presence of critical extrathoracic trauma (head, abdomen, or extremity AIS >3), GCS score ≤8, systolic blood pressure <90 mm Hg, and age >55 years. Separate multivariable analysis was performed, one for patients without and one for patients with associated critical extrathoracic injuries (head, abdomen, or extremity AIS >3), to compare the outcomes of the two therapeutic modalities adjusting for hypotension, GCS score ≤8, and age >55 years.

Results: One hundred ninety-three patients met the criteria for inclusion. Overall, 125 patients (64.9%) were selected for SG and 68 (35.2%) for OR. SG was selected in 71.6% of the 74 patients with major extrathoracic injuries and in 60.0% of the 115 patients with no major extrathoracic injuries. SG patients were significantly older than OR patients. Overall, 25 patients in the SG group (20.0%) developed 32 device-related complications. There were 18 endoleaks (14.4%), 6 of which needed open repair. Procedure-related paraplegia developed in 2.9% in the OR and 0.8% in the SG groups ($p = 0.28$). Multivariable analysis adjusting for severe extrathoracic injuries, hypotension, GCS, and age, showed that the SG group had a significantly lower mortality (adjusted odds ratio: 8.42; 95% CI: [2.76–25.69]; adjusted p value <0.001), and fewer blood transfusions (adjusted mean difference: 4.98; 95% CI: [0.14–9.82]; adjusted p value $= 0.046$) than the OR group. Among the 115 patients without major extrathoracic injuries, higher mortality and higher transfusion requirements were also found in the OR group (adjusted odds ratio for mortality: 13.08; 95% CI [2.53–67.53], adjusted p value $= 0.002$ and adjusted mean difference in transfusion units: 4.45; 95% CI [1.39–7.51]; adjusted p value $= 0.004$). Among the 74 patients with major extrathoracic injuries, significantly higher mortality and pneumonia rate were found in the OR group (adjusted p values 0.04 and 0.03, respectively). Multivariate analysis showed that centers with high volume of endovascular procedures had significantly fewer systemic complications (adjusted p value 0.001), fewer local complications (adjusted p value $p = 0.033$), and shorter hospital lengths of stay (adjusted p value 0.005) than low-volume centers.

Conclusions: Most surgeons select SG for traumatic thoracic aortic ruptures, irrespective of associated injuries, injury severity, and age. SG is associated with significantly lower mortality and fewer blood transfusions, but there is a considerable risk of serious device-related complications. There is a major and urgent need for improvement of the available endovascular devices.

Key Words: AAST multicenter study, Traumatic thoracic aorta, Open repair versus endovascular repair, Outcomes.

J Trauma. 2008;64:561–571.

Table 1 Comparison of Patient and Injury Characteristics Between Patients Who Had Operative Repair (OR) and Patients Who Had Endovascular Stent Graft (SG)

Characteristic	All Patients (N = 193)	Operative Repair (N = 68)	Endovascular Stent Graft (N = 125)	*p*
Gender				0.211
Percent (n) male	75.6 (146)	80.9 (55)	72.8 (91)	
Age				
Mean ± SD (n)	40.2 ± 18.7 (192)	34.1 ± 17.4 (68)	42.2 ± 18.1 (124)	<0.001
Percent (x/n) >55 yr	20.3 (39/192)	13.2 (9/68)	24.2 (30/124)	0.071
Percent (x/n) >70 yr	10.4 (20/192)	4.4 (3/68)	13.7 (17/124)	0.044
Mechanism of injury				
Percent (x/n) MVC	67.7 (130/192)	66.2 (45/68)	68.5 (85/124)	0.737
Percent (x/n) motorcycle	13.0 (25/192)	16.2 (11/68)	11.3 (14/124)	0.336
Percent (x/n) fall from height	7.3 (14/192)	5.9 (4/68)	8.1 (10/124)	0.774
Percent (x/n) auto vs. pedestrian	6.3 (12/192)	4.4 (3/68)	7.3 (9/124)	0.544
Percent (x/n) other mechanism	5.7 (11/192)	7.4 (5/68)	4.8 (6/124)	0.524
Hypotension at admission				0.207
Percent (x/n) yes	16.1 (31/193)	20.9 (14/67)	13.8 (17/123)	
GCS				0.923
Percent (x/n) ≤8	25.8 (49/190)	25.4 (17/67)	26.0 (32/123)	
ISS				0.826
Mean ± SD (n)	39.5 ± 11.7	38.9 ± 11.8	39.4 ± 11.3	
AIS				
Percent (x/n) head AIS >3	18.9 (36/190)	16.4 (11/67)	20.3 (25/123)	0.511
Percent (x/n) abdomen AIS >3	19.5 (37/190)	16.4 (11/67)	21.1 (26/123)	0.432
Percent (x/n) extremity AIS >3	9.5 (18/190)	4.5 (3/67)	12.2 (15/123)	0.083
Any severe associated injury				0.103
Percent (x/n) yes	39.2 (74/184)	31.3 (21/67)	43.4 (53/122)	
Diagnostic technique				
Percent (x) CT scan	93.3 (180)	86.8 (59)	96.8 (121)	0.013
Percent (x) angio	8.3 (16)	13.2 (9)	5.6 (7)	0.066
Percent (x) TEE	1.0 (2)	1.5 (1)	0.8 (1)	1.000
Percent (x) surgery	1.6 (3)	4.4 (3)	0.0 (0)	1.000
Type of TA injury				
Percent (x/n) intimal tear	20.5 (38/185)	19.7 (13/66)	21.0 (25/119)	0.832
Percent (x/n) aneurysm	58.4 (108/185)	57.6 (38/66)	58.8 (70/119)	0.869
Percent (x/n) dissection	25.4 (47/185)	28.8 (19/66)	23.5 (28/119)	0.431
Location of TA injury				
Percent (x/n) ascending	3.6 (4/111)	10.0 (4/40)	0 (0/71)	—
Percent (x/n) distal SCA	74.5 (82/110)	69.2 (29/39)	77.5 (55/71)	0.343
Percent (x/n) descending	21.8 (24/110)	20.5 (8/39)	22.5 (16/71)	0.806
Hours from injury to procedure				
Mean ± SD (n)	54.6 ± 101.6	67.6 ± 136.0	48.1 ± 77.6	0.416

x, number of events; n, number of subjects at risk for the derivation of the percent.

The *p* values for categorical variables were derived from two-tailed χ^2 test or Fisher's exact test; *p* values for continuous variables were derived from Student's *t* test or Mann-Whitney *U* test.

Table 3 Outcomes by Therapeutic Modality

Outcome	All Patients (N = 193)	Operative Repair (N = 68)	Endovascular Stent Graft (N = 125)	Odds Ratio (95% CI)	p*
Mortality					
Percent (x) died	13.0 (25)	23.5 (16)	7.2 (9)	3.97 (1.65 to 9.56)	0.001
Any systemic complications					
Percent (x) yes	45.1 (87)	50.0 (34)	42.4 (53)	1.36 (0.75 to 2.46)	0.311
Complications					
Percent (x/n) paraplegia†	1.6 (3/193)	2.9 (2/68)	0.8 (1/125)	3.76 (0.33 to 42.21)	0.284
Percent (x/n) pneumonia	33.0 (63/191)	35.8 (24/67)	31.5 (39/124)	1.22 (0.65 to 2.28)	0.540
Percent (x/n) ARDS	15.4 (29/188)	18.2 (12/66)	13.9 (17/122)	1.37 (0.61 to 3.08)	0.442
Percent (x/n) septicemia	14.4 (27/188)	14.9 (10/67)	14.0 (17/121)	1.07 (0.46 to 2.50)	0.870
Percent (x/n) UTI	18.6 (35/188)	20.9 (14/67)	17.4 (21/121)	1.26 (0.59 to 2.67)	0.550
Percent (x/n) graft sepsis	0.5 (1/187)	1.5 (1/67)	0.0 (0/121)	—	0.358
Percent (x/n) DVT	4.8 (9/188)	6.0 (4/67)	4.1 (5/121)	1.47 (0.38 to 5.68)	0.723
Percent (x/n) renal failure	9.1 (17/187)	10.4 (7/67)	8.3 (10/120)	1.28 (0.46 to 3.54)	0.630

Outcome	Mean ± SD (n) [Median]	Mean ± SD (n) [Median]	Mean ± SD (n) [Median]	Mean Difference (95% CI)	p‡
Ventilation days	9.2 ± 11.0 [5]	10.0 ± 14.3 [5]	8.8 ± 8.8 [5]	1.24 (−2.09 to 4.57)	0.893
ICU days	13.4 ± 12.0 [9]	14.0 ± 15.1 [9]	13.1 ± 10.0 [9]	0.89 (−2.73 to 4.51)	0.522
Hospital days	23.2 ± 32.2 [19]	27.3 ± 50.3 [21]	21.0 ± 14.6 [17]	6.30 (−3.42 to 16.02)	0.990
Blood transfusion units	10.3 ± 16.7 [6]	12.0 ± 19.1 [7]	9.5 ± 15.3 [5]	2.50 (−2.63 to 7.63)	0.095

* χ^2 test or two-sided Fisher's exact test.
† Procedure related.
‡ Student's t test or Mann-Whitney U test.

Table 3 Outcomes by Therapeutic Modality

Outcome	All Patients (N = 193)	Operative Repair (N = 68)	Endovascular Stent Graft (N = 125)	Odds Ratio (95% CI)	p*
Mortality					
Percent (x) died	13.0 (25)	23.5 (16)	7.2 (9)	3.97 (1.65 to 9.56)	0.001
Any systemic complications					
Percent (x) yes	45.1 (87)	50.0 (34)	42.4 (53)	1.36 (0.75 to 2.46)	0.311
Complications					
Percent (x/n)	1.6 (3/193)	2.9 (2/68)	0.8 (1/125)	3.76 (0.33 to 42.21)	0.284

Mortality
Percent (x) died 13.0 (25) 23.5 (16) 7.2 (9) 3.97 (1.65 to 9.56) 0.001

Outcome	All Patients (N = 193)	Operative Repair (N = 68)	Endovascular Stent Graft (N = 125)	Odds Ratio (95% CI)	p*
septicemia					
Percent (x/n) UTI	18.6 (35/188)	20.9 (14/67)	17.4 (21/121)	1.26 (0.59 to 2.67)	0.550
Percent (x/n) graft sepsis	0.5 (1/187)	1.5 (1/67)	0.0 (0/121)	—	0.358
Percent (x/n) DVT	4.8 (9/188)	6.0 (4/67)	4.1 (5/121)	1.47 (0.38 to 5.68)	0.723
Percent (x/n) renal failure	9.1 (17/187)	10.4 (7/67)	8.3 (10/120)	1.28 (0.46 to 3.54)	0.630

Outcome	Mean ± SD (n) [Median]	Mean ± SD (n) [Median]	Mean ± SD (n) [Median]	Mean Difference (95% CI)	p‡
Ventilation days	9.2 ± 11.0 [5]	10.0 ± 14.3 [5]	8.8 ± 8.8 [5]	1.24 (−2.09 to 4.57)	0.893
ICU days	13.4 ± 12.0 [9]	14.0 ± 15.1 [9]	13.1 ± 10.0 [9]	0.89 (−2.73 to 4.51)	0.522
Hospital days	23.2 ± 32.2 [19]	27.3 ± 50.3 [21]	21.0 ± 14.6 [17]	6.30 (−3.42 to 16.02)	0.990
Blood transfusion units	10.3 ± 16.7 [6]	12.0 ± 19.1 [7]	9.5 ± 15.3 [5]	2.50 (−2.63 to 7.63)	0.095

* χ^2 test or two-sided Fisher's exact test.
† Procedure related.
‡ Student's *t* test or Mann-Whitney *U* test.

Table 4 Adjusted Odds Ratio for Mortality and Complications (Operative Repair vs. Endovascular Stent Graft)

Outcome	Adjusted Odds Ratio (95% CI)*	Adjusted p*
Deaths	8.42 (2.76 to 25.69)	<0.001
Any systemic complications	1.41 (0.75 to 2.34)	0.290

* Multivariable analysis adjusting for severe extrathoracic trauma (any head or abdomen or extremities AIS >3, GCS score ≤8, SBP <90 mm Hg, and age >55 years).

Table 8 Adjusted Odds Ratio for Mortality and Complications in Patients Without Major Extrathoracic Injuries (Operative Repair vs. Endovascular Stent Graft)

Complication	Adjusted Odds Ratio (95% CI)*	Adjusted *p**
Deaths	13.08 (2.53 to 67.53)	0.002
Any systemic complications	1.15 (0.52 to 2.52)	0.732

* Multivariable analysis adjusting for GCS score ≤8, SBP <90 mm Hg, and age >55 years.

Table 11 Adjusted Odds Ratio for Mortality and Complications in Patients With Associated Major Extrathoracic Injuries (Operative Repair vs. Endovascular Stent Graft)

Outcome	Adjusted OR (95% CI)*	Adjusted *p**
Death	5.68 (1.09 to 29.45)	0.039
Any systemic complication	2.17 (0.70 to 6.09)	0.179
Pneumonia	3.49 (1.13 to 10.82)	0.030

* Multivariable analysis adjusting for GCS score ≤8, SBP <90 mm Hg, and age >55 years.

Table 13 Adjusted Odds Ratio Between Small and Large Centers (Centers <15 Procedures vs. Centers ≥15 Procedures) for Mortality and Complications in Endovascular Stent Graft Patients

Outcome	Adjusted OR (95% CI)*	Adjusted *p**
Deaths	0.23 (0.04 to 1.27)	0.092
Any systemic complications	3.88 (1.69 to 8.91)	0.001
Any local complications	2.70 (1.08 to 6.71)	0.033

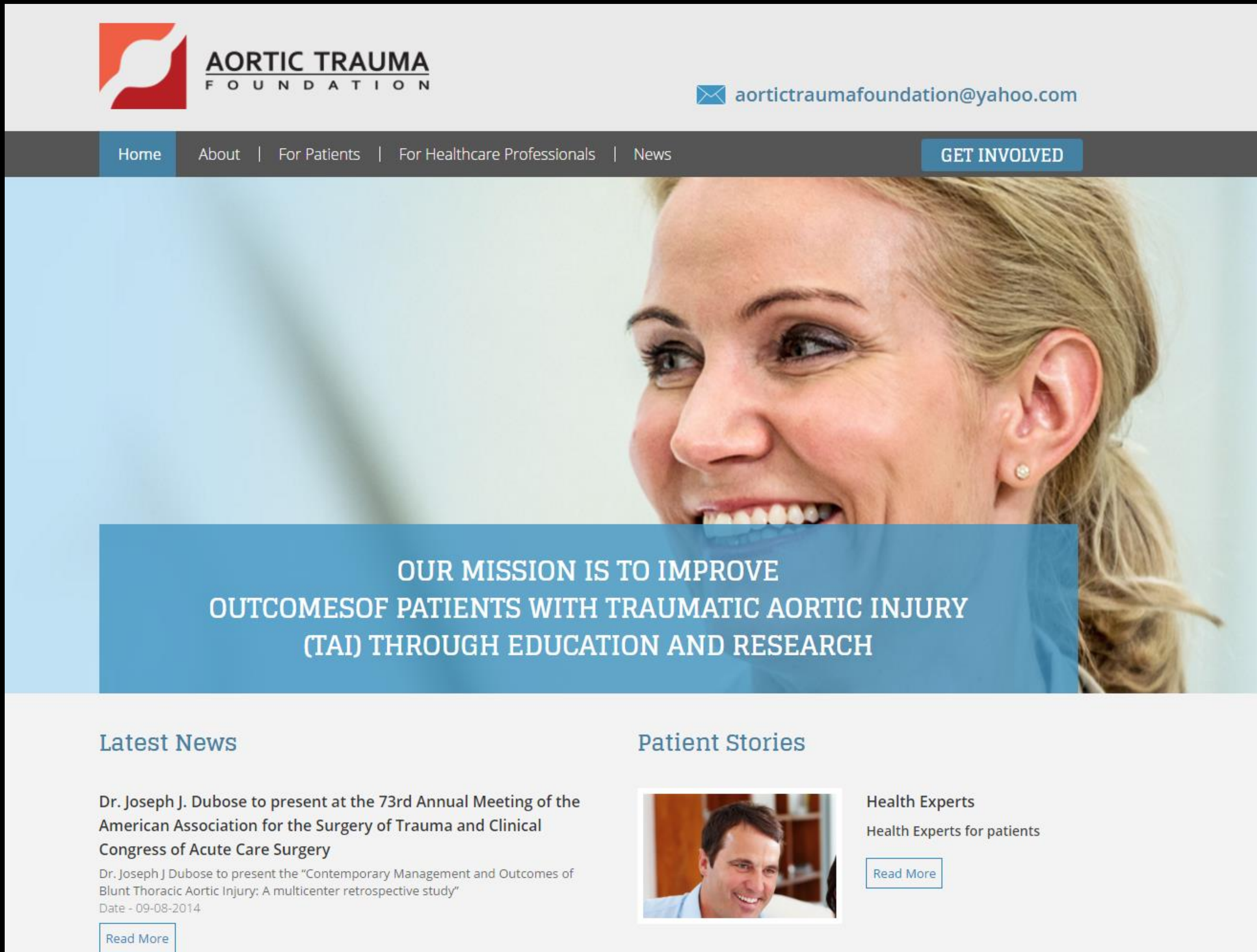
* Multivariable analysis adjusting for any severe extrathoracic trauma (head or abdomen or extremities AIS >3, GCS score ≤8, SBP <90 mm Hg, and age >55 years).

Traumatic Aortic Transection

Conclusion

Even with Endografts not designed for traumatic transection, The results are superior to open thoracotomy which can always be done safely later.

TEVAR should be the new Gold Standard for Traumatic Transection


AORTIC TRAUMA
FOUNDATION
aortictraumafoundation@yahoo.com
Home
About
For Patients
For Healthcare Professionals
News
GET INVOLVED
OUR MISSION IS TO IMPROVE
OUTCOMESOF PATIENTS WITH TRAUMATIC AORTIC INJURY
(TAI) THROUGH EDUCATION AND RESEARCH
Latest News
Dr. Joseph J. Dubose to present at the 73rd Annual Meeting of the American Association for the Surgery of Trauma and Clinical Congress of Acute Care Surgery
Dr. Joseph J Dubose to present the "Contemporary Management and Outcomes of Blunt Thoracic Aortic Injury: A multicenter retrospective study"
Date - 09-08-2014
Read More
Patient Stories
Health Experts
Health Experts for patients
Read More


Thank you