Surgery 000 (2018) 1–6

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

A nationwide study of treatment modalities for thoracic aortic injury☆,☆☆

Young-Ji Seo, Sarah E. Rudasill, Yas Sanaiha, Esteban Aguayo, Katherine L. Bailey, Vishal Dobaria, Peyman Benharash*

Division of Cardiac Surgery, David Geffen School of Medicine at the University of California, Los Angeles, CA

ARTICLE INFO

Article history:
Accepted 9 April 2018
Available online xxx

ABSTRACT

Background: Thoracic aortic injuries have traditionally been associated with high morbidity and mortality. Thoracic endovascular aortic repair has emerged as a suitable alternative to open repair, but its impact at a national level remains ill defined. This study aimed to analyze the national trends of patient characteristics, outcomes, and resource utilization in the treatment of thoracic aortic injuries.

Methods: Patients admitted with thoracic aortic injuries from 2005–2014 were identified in the National Inpatient Sample. Patients were identified as undergoing thoracic endovascular aortic repair, open surgery, or nonoperative management. The primary outcome was in-hospital mortality, while secondary outcomes included complications and costs. Multivariate regressions accounting for characteristics of the patients and injury characteristics were used to determine predictors of mortality and changes in cost.

Results: Of the 11,257 patients admitted for thoracic aortic injuries, 33% received thoracic endovascular aortic repair, 8% open surgery, and 59% nonoperative management. Thoracic endovascular aortic repair had the great largest growth in case volume ($P < .001$). Compared to open surgery, thoracic endovascular aortic repair patients had greater rates of concomitant brain (17 vs 26%, $P = .01$), pulmonary (21 vs 33%, $P < .001$), and splenic injuries (2 vs 4%, $P = .031$). In-hospital mortality was greater for open surgery (odds ratio = 3.06, $P = .003$) and nonoperative management (odds ratio = 4.33, $P < .001$) than thoracic endovascular aortic repair. Over time, mortality rates for thoracic endovascular aortic repair decreased ($P = .002$), but increased for open surgery ($P = .04$). Interestingly, total costs with thoracic endovascular aortic repair increased ($P = .004$), while they decreased for open surgery ($P = .031$).

Conclusion: Our findings indicate the rapid adoption of thoracic endovascular aortic repair over open surgery for management of thoracic aortic injuries. Thoracic endovascular aortic repair is associated with lower mortality rates, but it has greater costs not otherwise explained by other patient factors.

Introduction

Despite a low incidence, thoracic aortic injuries (TAIs) caused by trauma remain a substantial cause of morbidity and mortality.[1] Based on limited single-institution series, 80% of TAIs result in immediate mortality,[2] often caused by shearing forces from the sudden deceleration of motor vehicles and falls.[3-5] Open surgical repair requiring thoracotomy, single-lung ventilation, and cardiopulmonary bypass has been the standard treatment for TAIs since 1959.[4] This major operative procedure, however, is associated with high rates of complications and mortality, especially given the frequency of concomitant injuries in TAI patients.[6]

Thoracic endovascular aortic repair (TEVAR) is a less invasive approach that deploys prefitted grafts in the thoracic aorta, thus avoiding thoracotomy and single-lung ventilation.[3] The technique was first utilized for the treatment of TAIs in 1997 and gained FDA approval for the first commercial graft in 2005.[7,8] Since that time, multiple institutional studies have reported lower mortality rates for patients undergoing TEVAR relative to open surgical repair.[9-16] In addition to decreased mortality, patients undergoing TEVAR experience lower rates of complications, including paraplegia, pneumonia, acute renal failure, and postoperative infection.[10,14-17]

Although the use of TEVAR for the treatment of TAI has supplanted open repair at institutions with endovascular expertise, adoption of this technology and its impact on other treatment modalities at a national level remain ill defined. Resource utilization for various modalities is rarely reported, and studies report-

☆ Presented at the 13th Annual Academic Surgical Congress in Jacksonville, FL, January 30 to February 1, 2018.

☆☆ The authors have no conflicts of interest to disclose.

* Corresponding author at Peyman Benharash, MD, UCLA Division of Cardiac Surgery, Los Angeles, CA 90095.

E-mail address: pbenharash@mednet.ucla.edu (P. Benharash).

https://doi.org/10.1016/j.surg.2018.04.015
0039-6060/

Table 1
Baseline characteristics of nonoperative, open, and TEVAR strategies.

Characteristic	Nonoperative ($n = 6657$)	Open ($n = 872$)	TEVAR ($n = 3728$)	P value*
Demographics				
Sex (female)	1867 (28%)	225 (26%)	932 (25%)	.809
Age (mean ± SD)	45.7 ± 19.2	40.7 ± 18.1	43.2 ± 18.2	.095
Comorbidities				
Elixhauser index	1.5 ± 1.5	1.5 ± 1.5	1.7 ± 1.5	.147
Congestive heart failure	427 (4%)	14 (2%)	55 (1%)	.887
Coronary artery disease	181 (3%)	10 (1%)	36 (1%)	.811
Hypertension	1378 (21%)	131 (15%)	767 (21%)	.116
Diabetes	368 (5%)	<10	193 (5%)	.005
Chronic pulmonary disease	256 (4%)	24 (3%)	115 (3%)	.792
Renal failure	95 (1%)	<10	49 (1%)	.785
Peripheral vascular disease	493 (7%)	118 (13%)	563 (15%)	.601
Concomitant injuries				
Brain injury	1518 (23%)	145 (17%)	967 (26%)	.011
Skull fracture	1031 (15%)	138 (16%)	680 (18%)	.478
Thoracic injury				
Hemothorax	1893 (28%)	193 (22%)	1210 (32%)	.004
Cardiac	272 (4%)	14 (2%)	148 (4%)	.128
Pulmonary	1799 (27%)	181 (21%)	1218 (33%)	<.001
Abdominal injury				
Liver	1380 (21%)	187 (21%)	900 (24%)	.42
Spleen	1446 (22%)	150 (17%)	938 (25%)	.031
Kidney	730 (11%)	89 (10%)	49 (13%)	.307
Pelvic	184 (3%)	19 (2%)	103 (3%)	.708
Gastrointestinal	639 (10%)	84 (10%)	406 (11%)	.638
Vertebral injury				
With spinal cord injury	258 (4%)	233 (3%)	143 (4%)	0.46
Without spinal cord injury	2058 (31%)	241 (28%)	1344 (36%)	.035
Major orthopedic injury	2971 (45%)	405 (46%)	1949 (52%)	.125
Total injuries (mean ± SD)	2.4 ± 1.8	2.1 ± 1.7	2.8 ± 1.9	<.001
Days to procedure (mean ± SD)	–	1.9 ± 6.1	2.4 ± 7.9	.465
Other required interventions				
Intracranial	75 (1%)	<10	60 (2%)	.297
Cardiac	2314 (35%)	329 (38%)	1258 (34%)	.307
Lung	120 (2%)	18 (2%)	40 (1%)	.261
Liver	217 (3%)	30 (3%)	102 (3%)	.55
Spleen	457 (7%)	45 (5%)	232 (6%)	.574
Kidney	73 (1%)	<10	15 (0.4%)	.83
Pelvic organs	183 (3%)	<10	100 (3%)	.44
Gastrointestinal tract	1439 (22%)	224 (26%)	806 (22%)	.226

* P value is for comparison of open and TEVAR surgery.

ing costs have yielded conflicting findings.[14,16,18] The present study was performed using the National Inpatient Sample (NIS) to analyze trends of patient characteristics and resource utilization in the treatment of TAIs. With rapid evolution of endovascular technologies, elucidating the use of TEVAR relative to open surgical repair and nonoperative management would be important in optimization of patient outcomes and health system operations.

Methods

Study cohort

The NIS was used to identify all patients (>18 years) who had a hospital admission for TAI. NIS is an all-payer, administrative inpatient database maintained by the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP) that estimates more than 35 million US hospitalizations every year. The NIS is drawn from all states participating in the HCUP, thus representing more than 97% of the US population and approximating a 20% stratified sample of all US community hospitals. This study was deemed exempt by the institutional review board of the University of California, Los Angeles.

Using the *International Classification of Disease, Ninth Revision—Clinical Modification* (ICD-9-CM) codes, we identified all adults who were admitted with a diagnosis of TAI (901.0) between 2005 and 2014. Patients were categorized into 3 groups based on management strategy: TEVAR if undergoing an endovascular graft implantation to thoracic aorta (39.73), open if undergoing thoracotomy and aortic replacement (38.45), and nonoperative if managed with neither TEVAR nor open repair. Patients who converted from TEVAR to open surgery ($n = 3$, raw) were excluded from the study.

Patient and operative characteristics of interest included sex, age, comorbidities, concomitant injuries, and other interventions employed, as outlined in Table 1. The Elixhauser comorbidity index was used to determine the severity of comorbidities, which is based on the presence of 30 comorbid diseases with differential weights.[19] The primary outcome of interest was mortality. Other endpoints included complication rates, duration of hospitalization, discharge status, and costs of care.

Statistical analysis

All sample sizes listed in this study are national estimates performed by Stata's (SVY) commands (Stata Corporation, College Station, TX) to account for the stratified cluster design of the NIS and the individual hospital's discharge-level weights. Categorical variables were presented as counts and percentages, and continuous variables as means and standard deviations. Comparisons between categorical variables were made with χ^2 tests, and Student's t test was used for continuous variables. Costs were standardized to the 2014 gross domestic product using US Department of Commerce consumer price indices. For multivariate regressions, costs were converted to a logarithmic scale to decrease the spread of the cost and to linearize the relationship.

Please cite this article as: Y.-J. Seo et al., A nationwide study of treatment modalities for thoracic aortic injury, Surgery (2018), https://doi.org/10.1016/j.surg.2018.04.015