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The impact of endovascular repair on management and outcome of ruptured thoracic aortic aneurysms

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ABSTRACT

Background: Thoracic endovascular aortic repair (TEVAR) has become an alternative to open repair for the treatment of ruptured thoracic aortic aneurysms (rTAAs). The aim of this study was to assess national trends in the use of TEVAR for the treatment of rTAA and to determine its impact on perioperative outcomes.

Methods: Patients admitted with an rTAA between 1993 and 2012 were identified from the National Inpatient Sample. Patients were grouped in accordance with their treatment: TEVAR, open repair, or nonoperative treatment. The primary outcomes were treatment trends over time and in-hospital death. Secondary outcomes included perioperative complications and length of stay. Trend analyses were performed using the Cochran-Armitage test for trend, and adjusted mortality risks were established using multivariable logistic regression analysis.

Results: A total of 12,399 patients were included, with 1622 (13%) undergoing TEVAR, 2808 (23%) undergoing open repair, and 7969 (64%) not undergoing surgical treatment. TEVAR has been increasingly used from 2% of total admissions in 2003-2004 to 43% in 2011-2012 ($P < .001$). Concurrently, there was a decline in the proportion of patients undergoing open repair (29% to 12%; $P < .001$) and nonoperative treatment (69% to 45%; $P < .001$). The proportion of patients undergoing surgical repair has increased for all age groups since 1993-1994 ($P < .001$ for all) but was most pronounced among those aged 80 years with a 7.5-fold increase. After TEVAR was introduced, procedural mortality decreased from 36% in 2003-2004 to 27% in 2011-2012 ($P < .001$); mortality among those undergoing nonoperative treatment remained stable between 63% and 60% ($P = .167$). Overall mortality after rTAA admission decreased from 55% to 42% ($P < .001$). Since 2005, mortality for open repair was 33% and 22% for TEVAR ($P < .001$). In adjusted analysis, open repair was associated with a twofold higher mortality than TEVAR (odds ratio, 2.0; 95% confidence interval, 1.7-2.5).

Conclusions: TEVAR has replaced open repair as primary surgical treatment for rTAA. The introduction of endovascular treatment appears to have broadened the eligibility of patients for surgical treatment, particularly among the elderly. Mortality after rTAA admission has declined since the introduction of TEVAR, which is the result of improved operative mortality as well as the increased proportion of patients undergoing surgical repair. (J Vasc Surg 2017;■:1-10.)

A ruptured descending thoracic aortic aneurysm (rTAA) is a life-threatening diagnosis, with an estimated mortality exceeding 90%.[1] The majority of patients die before making it to the emergency department. For those hemodynamically stable enough to reach the hospital and to undergo surgery,[1] traditional open repair requires an emergency thoracotomy to replace the diseased aorta with an interposition graft. Despite the fact that hospitalized patients are presumed to have a better prognosis, mortality after surgery is as high as 45%,[2,3] with surviving patients often suffering disabling complications, such as paraplegia and stroke.[2,4-6]

As a minimally invasive alternative, thoracic endovascular aortic repair (TEVAR) for rTAA was first introduced and described by Semba et al in 1997.[7,8] In subsequent years, single-institution studies were performed to evaluate its feasibility and performance compared with conventional open repair.[4,9-14] Although some of these studies showed encouraging perioperative results favoring TEVAR, they were often limited by small numbers and the inclusion of other acute aortic diseases. Moreover, an absolute perioperative survival benefit of TEVAR over open repair could not be confirmed.[4,14] Reports on outcome of rTAA using early national data from the National Inpatient Sample (NIS) yielded conflicting results, despite the same cohort of TEVAR patients.

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Previous studies have demonstrated that for patients presenting with a traumatic thoracic aortic injury, the introduction of TEVAR has reduced the proportion of patients managed nonoperatively.[15,16] For rTAA patients, however, it is unknown whether the introduction of TEVAR has broadened their treatment eligibility.[15] The purpose of this study was to assess national trends in the treatment of rTAA, focusing on the relative use and outcome of TEVAR, open repair, and nonoperative treatment.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected National Inpatient Sample (NIS) database
- **Take Home Message:** In 12,399 patients with ruptured thoracic aortic aneurysms (rTAAs), thoracic endovascular aortic repair (TEVAR) has replaced open repair as primary treatment for rTAA. In 2011-2012, 43% of rTAAs were repaired with TEVAR, with a mortality of 22%. In adjusted analysis, TEVAR had a twofold lower mortality than open repair.
- **Recommendation:** The authors recommend TEVAR for repair of rTAAs. TEVAR results in improved hospital survival and increases availability for intervention, particularly in the elderly.

METHODS

For this study, we used the NIS. The NIS is the largest U.S. all-payer inpatient database; it is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. From the U.S. states participating in the Healthcare Cost and Utilization Project, which represent 96% of the U.S. population in more recent years, a 20% stratified sample of hospitals is selected to accurately represent hospital admissions nationally.[17] Actual annual U.S. hospitalization volumes are approximated using hospital sampling weights. The weighted estimates are used for all analyses in this study, as recommended by the Agency for Healthcare Research and Quality. The Institutional Review Board of Beth Israel Deaconess Medical Center approved this study, and consent of the patient was waived because of the deidentified nature of the data.

Patients were identified using *International Classification of Diseases, Ninth Revision* codes. All patients admitted with an rTAA (411.1) were identified. Patients were subsequently divided into the open repair group (38.35) and the TEVAR group (39.73). Those with a primary diagnosis of a ruptured aneurysm without mention of any procedure were considered nonoperatively treated. In an effort to capture TEVAR cases before TEVAR procedure coding was introduced in 2005, patients with a primary diagnosis of an rTAA in combination with mention of endovascular aneurysm repair (39.71) or insertion of non-drug-eluting peripheral (noncoronary) vessel stent (39.90) were also considered to have undergone endovascular repair. Patients with a procedure code for both open repair and TEVAR were excluded. In addition, those with a concomitant diagnosis for thoracoabdominal aneurysm (diagnosis codes 441.3 to 441.9 or procedure codes 38.44 and 39.71), aortic dissection (diagnosis codes 441.00 to 441.03), or connective tissue disorder (diagnosis codes 446.0-446.7, 758.6, and 759.82) were excluded from this study. To separate ascending from descending aneurysms, patients with procedure codes for cardioplegia (39.63), valve surgery (35.00-35.99), and procedures on the vessels of the heart (36.00-36.99, 37.0, 37.2, 37.31-37.90, 37.93, and 37.99) were also excluded as they are more likely to represent aneurysms of the ascending aorta.

We compared patient demographics (age, gender, race) and comorbid conditions (coronary artery disease, diabetes, hypertension, heart failure, chronic obstructive pulmonary disease, chronic kidney disease, and cerebrovascular disease). We additionally assessed differences in hospital characteristics, including hospital bed size (small, medium, large), setting, and teaching status (rural, urban nonteaching, urban teaching). Hospital bed size category varies according to location and teaching status. Small hospital bed size is defined as 1 to 49, 50 to 99, and 1 to 299 beds, respectively, for rural, urban nonteaching, and urban teaching hospitals; medium bed size is defined as 50 to 99, 100 to 199, and 300 to 499, respectively; and a large bed size hospital is considered 100+, 200+, and 500+ beds, respectively. Adverse in-hospital outcomes included death, cardiac or respiratory complications, paraplegia, stroke, acute renal failure, wound dehiscence, and infection. Cardiac complications included postoperative myocardial infarction, cardiac arrest, cardiogenic shock, and ventricular fibrillation (Supplementary Table, online only). A respiratory complication was defined as a postoperative pneumonia, pulmonary insufficiency after trauma or surgery, transfusion-related acute lung injury, or acute respiratory failure. Discharge to home and length of stay were additionally documented. Comparative analysis of the different treatment approaches is limited to the years 2005 to 2012 because this was the period during which both treatment approaches were available.

For this study, we also used the Wide-ranging Online Data for Epidemiologic Research (WONDER), an epidemiologic Internet-based database maintained by the Centers for Disease Control and Prevention,[18] to assess national cause-specific age-adjusted death rates due to thoracic aortic aneurysms (*International Classification of Diseases, Tenth Revision* code S25.0). More information on WONDER can be found on http://wonder.cdc.gov/.

Statistical methods. Baseline characteristics were described as counts and percentages (dichotomous