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Nationwide trends and regional/hospital variations in open versus endovascular repair of thoracoabdominal aortic aneurysms

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Objectives: Thoracic endovascular aortic repair (TEVAR) has been gaining popularity for the treatment of thoracoabdominal aortic aneurysm (TAAA). We used a nonvoluntary database to examine national trends and regional/hospital variations in the use of TEVAR and open thoracic aortic repair (OTAR) for TAAA.

Methods: From the 2005-2008 Nationwide Inpatient Sample database, we identified all patients with the diagnosis of TAAA who were treated with TEVAR or OTAR. Rates of these procedures were compared between years, across geographic regions, and between hospitals of various bed sizes.

Results: Over the study period, the rate of OTAR remained relatively stable (range, 7.5/100 patients in 2005 to 10.1/100 patients in 2008; $P = .26$), whereas the rate of TEVAR increased dramatically (range, 1.4/100 patients in 2005 to 6.3/100 patients in 2008; $P < .0001$). In 2008, 29% (211) of all TEVAR procedures and 11% (130) of all OTAR procedures were performed in western regions of the United States ($P = .03$). Additionally, 13% (95) of all TEVAR procedures and 3% (35) of all OTAR procedures were performed in smaller hospitals ($P < .0001$).

Conclusions: The use of TEVAR for TAAA repair increased significantly over the study period, whereas OTAR rates remained relatively stable. Our findings suggest that more patients who were otherwise not surgical candidates or did not have traditional surgical indications for OTAR were treated with TEVAR, most commonly in regions or hospitals where OTAR is less often performed. Given the complexity of TAAA cases, these results may have significant implications for patient safety in the current era of heightened health care scrutiny. (J Thorac Cardiovasc Surg 2012;144:612-6)

After endovascular techniques were developed for the management of abdominal aortic aneurysms in 1991, they competed with open aortic repair and have become the primary treatment modality for many patients with isolated aortic aneurysms.[1-3] Endovascular interventions for aneurysm repair were further refined after the technology for thoracic endovascular aortic repair (TEVAR) was approved by the US Food and Drug Administration in 2005 for use in the repair of thoracic aortic aneurysms,[4] leading to an increased use of stent grafts in repairing some thoracic aortic aneurysms. Since then, TEVAR has been rapidly gaining popularity.

Preliminary short-term data regarding the use of TEVAR to treat thoracic aortic aneurysms have been promising.[5] Intermediate outcomes for TEVAR in the treatment of thoracic aortic aneurysms, first described in several single-center studies,[6] were further elucidated in a nationwide study that aimed to address TEVAR's national utility and that associated TEVAR with better in-hospital outcomes, shorter lengths of stay, and fewer complications than open thoracic aortic repair (OTAR).[7]

Thoracoabdominal aortic aneurysm (TAAA) is a rare but complex and potentially lethal disease with relatively high perioperative morbidity and mortality. Historically, TAAA has required open surgical repair.[8,9] The overall rupture rate is estimated to be as high as 26%,[10] and rupture is associated with an overall mortality rate of 20.3%.[11] Postrepair and perioperative mortality rates from experienced centers range from approximately 4% to 16%.[12-16] Given the relatively high morbidity and mortality of open surgical TAAA repair, less-invasive TEVAR procedures with adjunctive surgical visceral vessel debranching (hybrid approach) and TEVAR alone with specialized branched endografts have slowly emerged as feasible and promising alternatives.[17-20]

However, little is known about regional and hospital variation in the use of TEVAR for the treatment of TAAA. We examined nationwide trends and attempted to determine whether there is any regional or hospital variation in the use of TEVAR versus OTAR for the treatment of TAAA.

MATERIALS AND METHODS

Data Source

Data were collected from the 2005-2008 Nationwide Inpatient Sample (NIS). The NIS is a database of hospital inpatient stays and is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project (HCUP).[21] The NIS is the largest all-payer

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Abbreviations and Acronyms

HCUP = Healthcare Cost and Utilization Project
ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification
NIS = Nationwide Inpatient Sample
OTAR = open thoracic aortic repair
TAAA = thoracoabdominal aortic aneurysm
TEVAR = thoracic endovascular aortic repair

inpatient care database, representing 20% of all hospital discharges from nonfederal facilities within the United States. The NIS has numerous internal quality assurance procedures that check the consistency and validity of data points (http://www.hcup-us.ahrq.gov/db/quality.jsp). Furthermore, HCUP validates the NIS annually by comparing its contents with those of 2 similar databases, the National Hospital Discharge Survey and the Medicare Provider Analysis and Review, to assess potential biases in the dataset (http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp). The NIS contains data on approximately 8 million hospital stays each year from more than 1000 hospitals. Weights based on sampling probabilities for each stratum are used in the analysis to ensure that the hospitals studied are representative of all US hospitals. Five hospital sampling strata were defined according to hospital characteristics contained in the American Hospital Association Annual Survey of Hospitals. The stratification variables were geographic region (Appendix Table 1), location (urban or rural), teaching status, control (public or proprietary), and bed size (Appendix Table 2).

This study was approved by the Institutional Review Board of Baylor College of Medicine. The reported data conform to the data-use agreement for the NIS from the HCUP. Additional information about NIS is available from the Agency for Healthcare Research and Quality, which administers the database as part of the HCUP (http://www.hcup-us.ahrq.gov/nisoverview.jsp).

Patient Selection

Patient identification was based on the 2008 International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes.[22] We used the these codes to query the 2005-2008 NIS database for our patient selection. The ICD-9 diagnosis codes 4416 and 4417 were used to identify all patients with TAAA. Within this group of patients, the ICD-9 procedure codes 3835 and 3845 were used to identify patients who underwent OTAR only without any endovascular intervention, and procedure code 3973 was used to identify patients who underwent TEVAR with or without a hybrid debranching procedure. We excluded patients who underwent both TEVAR and OTAR during the same index hospitalization in an attempt to exclude emergency open conversions from our final analysis.

We found a total of 39,135 records of patients with the diagnosis of TAAA who were discharged from a hospital during the 4-year study period. Of these patients, 2911 underwent OTAR only, and 1838 underwent TEVAR alone with branched endografts or TEVAR with a hybrid visceral debranching procedure.

Statistical Analysis

NIS database discharge weights were used to produce national estimates for all analyses. Rates of TEVAR and OTAR were then compared by year, geographic region (Appendix Table 1), and hospital bed size (Appendix Table 2) by using the Rao-Scott χ^2 test. All data were analyzed with SAS/STAT software, version 9.1, of the SAS System for the XP PRO platform (SAS Institute Inc, Cary, NC).

RESULTS

As shown in Figure 1, the rate of OTAR remained relatively stable over the study period (7.5/100 TAAA patients in 2005 vs 10.1/100 TAAA patients in 2008; $P = .26$). In contrast, the rate of TEVAR increased significantly, from 1.4/100 TAAA patients in 2005 to 6.3/100 TAAA patients in 2008 ($P < .0001$).

In the most recent data set (from 2008), 29% of all TEVAR procedures were performed in western regions of the United States (as defined in Appendix Table 1), whereas only 11% of all OTAR procedures were performed in those regions (Table 1). Similarly, in 2008, 13% of all TEVAR procedures were performed in small bed size hospitals (as defined in Appendix Table 2), whereas only 3% of all OTAR procedures were performed in small hospitals (Table 2).

DISCUSSION

We found that whereas OTAR rates remained relatively stable over the 4-year study period, TEVAR rates significantly increased over the same period for the treatment of TAAA. Moreover, the rates of TEVAR and OTAR varied among regions and by hospital bed size, in that more TEVAR procedures than OTAR procedures were performed in western regions of the United States and in smaller hospitals across the country.

Because of both the minimal invasiveness of TEVAR compared with OTAR and patient-driven demand for TEVAR technology, TEVAR rates for the treatment of TAAA rapidly increased between 2005 and 2008, whereas rates of OTAR for TAAA remained relatively unchanged during the same period. Although these results are not unexpected, the regional and hospital variation in the use of these procedures is a novel finding and may have significant implications.

Open surgical TAAA repairs are complex surgical procedures, the outcomes of which have been shown to be best at high-volume centers with high-volume surgeons.[23] For this reason, OTAR for TAAA repair often requires a dedicated team of surgeons, anesthesiologists, ancillary support staff, and hospital resources to achieve optimal outcome. Although TEVAR is less invasive than OTAR, intraoperative conversion to emergency OTAR—the probability of which is not insignificant—carries a high mortality and morbidity rate.[24]

Our study shows significant regional and hospital variation in the rates of TEVAR and OTAR procedures for the treatment of TAAA. Specifically, a higher percentage of TEVAR procedures than OTAR procedures was performed in western regions of the United States and in smaller hospitals (Tables 1 and 2). When complications from TEVAR procedures occur in regions or hospitals where OTAR is less commonly performed, emergency open conversion must be done in a setting where resources and experience may be limited. This situation is probably not uncommon, because conversion to OTAR is necessary in approximately 4% of TEVAR procedures performed to treat thoracic aortic disease of any sort.[24] The outcomes of these emergency conversions may be compromised in such cases.

Regional variations in the rates of TEVAR identified in our study may have been due to population density variance