National trends in open surgical, endovascular, and branched-fenestrated endovascular aortic aneurysm repair in Medicare patients

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ABSTRACT

Background: Open repair effectively prevents rupture for patients with abdominal aortic aneurysm (AAA) and is commonly studied as a metric reflecting hospital and surgeon expertise in cardiovascular care. However, given recent advances in endovascular aneurysm repair (EVAR), such as branched-fenestrated EVAR, it is unknown how commonly open surgical repair is still used in everyday practice.

Methods: We analyzed trends in open AAA repair, EVAR, and branched-fenestrated EVAR for AAA in Medicare beneficiaries from 2003 to 2013. We used Medicare Part B claims to ascertain counts of these repair types annually during the study period. We assessed regional and national trends in characteristics of the patients and procedure volume.

Results: Between 2003 and 2013, the total number of AAA repairs performed in fee-for-service Medicare patients declined by 26% from 31,582 to 23,421 ($P < .001$), after a peak number of 32,540 was performed in 2005 (28% decline since 2005). The number of open AAA repairs steadily declined by a total of 76%, from 20,533 in 2003 to 4916 in 2013 ($P < .001$). Whereas the number of EVARs increased from 11,049 in 2003 to 19,247 in 2011 ($P < .001$), it has since declined a total of 15% to only 16,362 repairs in 2013 ($P < .001$). After its introduction in 2011, the number of branched-fenestrated EVAR cases continuously rose from 335 procedures in 2011 to 2143 procedures in 2013 ($P < .001$). By 2013, virtually all hospital referral regions in the United States had rates of open AAA repair that would have been in the lowest quintile of volume in 2003.

Conclusions: The number of open AAA repairs fell by nearly 80% during the last decade, whereas traditional EVAR declined slightly and branched-fenestrated EVAR rapidly disseminated into national practice. These results suggest that open AAA repair is now performed too infrequently to be used as a metric in the assessment of hospital and surgeon quality in cardiovascular care. Furthermore, surgical training paradigms will need to reflect the changing dynamics necessary to ensure that surgeons and interventionists can safely perform these high-risk surgical procedures. (J Vasc Surg 2017;■:1-8.)

Abdominal aortic aneurysm (AAA) is the 15th leading cause of death among people older than 65 years in the United States.[1] Because it is a technically complex, high-risk procedure with readily measurable complications such as mortality,[2,3] open AAA repair has been traditionally used to assess quality in vascular care by numerous quality assurance organizations, federal agencies, national insurers, and researchers.[4,5] Finally, the number of open AAA repairs performed by surgical trainees is an often-studied marker of the size and prestige of vascular surgery training programs.[6-9]

However, endovascular aneurysm repair (EVAR) began to steadily replace open AAA repair beginning in September 1999, when the Food and Drug Administration approved the use of endovascular devices for patients with AAA.[10] Although it was initially limited to aneurysms with adequate normal infrarenal aorta, the last decade has seen considerable progress in techniques such as branched EVAR to allow endovascular repair for aneurysms involving the renal and visceral arteries.[11,12] The first generation of branched-fenestrated EVAR devices gained Food and Drug Administration approval in 2011, just over a decade after infrarenal EVAR became widely available.[13]

For several years now, a multitude of treatment options—open surgical repair, EVAR, and branched-fenestrated EVAR—have existed for patients facing treatment for AAA.[3,10,13,14] Whereas each of these modalities is used commonly for certain patients and treatment settings, a clear distribution of the current practice trends is not readily available. By understanding

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treatment trends and changes over time, we can better assess the applicability of open aortic aneurysm repair as a quality measure and as a guideline for surgical training. Furthermore, we can learn about the adaptation of complex endovascular aortic repair geographically over time. For these reasons, we used Medicare claims to examine the regional and national use of AAA repair types—open surgical repair, EVAR, and branched-fenestrated EVAR—between 2003 and 2013.

METHODS

Overall analysis. Using national data sets from Medicare claims,[15] we conducted a series of trend analyses. First, we used Part B Medicare claims to examine secular trends in the use of different types of AAA repair in fee-for-service Medicare patients. Second, we used the 307 hospital referral regions as defined in the *Dartmouth Atlas of Healthcare*[16] to examine regional rates of the use of AAA repair overall as well as the rates of each of the individual procedures over time. Finally, we examined patient-level demographics, comorbidities, and in-hospital outcomes, both overall and for each individual AAA repair type.

Secular trend analyses of AAA procedures. We used the *International Classification of Diseases, Ninth Revision* procedure codes described in the Supplementary Table (online only) to identify fee-for-service Medicare patients treated for infrarenal and paravisceral AAA between 2003 and 2013. We excluded ruptured aneurysm repairs as well as aneurysms with a thoracic component. The unit of analysis was the patient, and each patient was assigned to the first procedure type reported in Medicare claims. We used the total number of procedures per year divided by the midyear population of Medicare beneficiaries to calculate procedure counts as well as procedure rates per 100,000 Medicare beneficiaries.

Regional rates over time. Next, we examined the regional rates of each type of aortic aneurysm repair between 2003 and 2013, using the hospital referral regions defined in the *Dartmouth Atlas of Healthcare*.[16] We calculated both individual procedure counts and procedure rates per 1000 Medicare patients per year, using the Medicare patient population from the Denominator File for each individual year.[15] Regions take into account the location of the patient's recorded address rather than that of the institution at which the procedure is performed.

Analysis of demographics, comorbidities, and outcome. We recorded the average age, race, and gender of each of the patients studied in our cohort. We also examined the Charlson Comorbidity Index for each patient at the time of surgical treatment[17] and then measured in-hospital mortality rates. Mortality rates were similarly assessed for patients who underwent AAA repair for nonruptured aneurysms without a thoracic component. We used nonparametric tests of trend to assess differences in repair rates over time.

Our study was approved by the Center for Protection of Human Subjects at Dartmouth's Geisel School of Medicine. Informed consent was not necessary, given the deidentified nature of all data. All analyses were performed using Stata software, version 13 (StataCorp LP, College Station, Tex).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective review of prospectively maintained Medicare database
- **Take Home Message:** Between 2003 and 2013, the total number of abdominal aortic aneurysm (AAA) repairs in Medicare patients declined by 26% from 31,582 to 23,421. The number of open AAA repairs fell by 76%, from 20,533 in 2003 to 4916 in 2013; endovascular repair increased from 11,049 in 2003 to 19,247 in 2011, then declined to 16,362 in 2013; and branched endovascular repair increased from 335 in 2011 to 2143 in 2013.
- **Recommendation:** This study suggests that open AAA repairs are too infrequent to be used as a surgeon or hospital quality metric and that surgical training will need to adjust.

RESULTS

Overall trends in AAA repair. We found that between 2003 and 2013, the number of AAA repairs performed in fee-for-service Medicare beneficiaries declined from 31,582 procedures in 2003 to 23,421 in 2013. The absolute highest number of procedures was performed in 2004 and represented >32,000 procedures per year in fee-for-service Medicare patients. Patients undergoing EVAR were an average 76 years old; those undergoing open AAA repair were approximately 74 years old (Table). These ages did not change significantly over time. Finally, age ranges for branched-fenestrated EVAR were more similar to those for EVAR than for open repair (Table).

Secular trends in open AAA repair, EVAR, and branched EVAR. Between 2003 and 2013, the number of open AAA repairs in Medicare patients declined by 76%, from 20,533 procedures in 2003 to 4916 procedures in 2013. EVAR procedures increased between 2003 and 2011, from 11,049 procedures in 2003 to a peak of 19,247 procedures in 2011, a 74% increase during that period ($P < .001$). Rates of EVAR then began to decline in 2012, falling 15% compared with the highest rates seen between 2011 and 2013 ($P < .001$; Fig 1).

The decline in traditional EVAR occurred at the same rate at which branched-fenestrated EVAR began to