The impact of endovascular repair on specialties performing abdominal aortic aneurysm repair

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Background: **Abdominal aortic aneurysm (AAA) repair has been performed by various surgical specialties for many years. Endovascular aneurysm repair (EVAR) may be a disruptive technology, having an impact on which specialties care for patients with AAA. Therefore, we examined the proportion of AAA repairs performed by various specialties over time in the United States and evaluated the impact of the introduction of EVAR.**

Methods: **The Nationwide Inpatient Sample (2001-2009) was queried for intact and ruptured AAA and for open repair and EVAR. Specific procedures were used to identify vascular surgeons (VSs), cardiac surgeons (CSs), and general surgeons (GSs) as well as interventional cardiologists and interventional radiologists for states that reported unique treating physician identifiers. Annual procedure volumes were subsequently calculated for each specialty.**

Results: **We identified 108,587 EVARs and 85,080 open AAA repairs (3011 EVARs and 12,811 open repairs for ruptured AAA). VSs performed an increasing proportion of AAA repairs during the study period (52% in 2001 to 66% in 2009; $P < .001$). GSs and CSs performed fewer repairs during the same period (25% to 17% [$P < .001$] and 19% to 13% [$P < .001$], respectively). EVAR was increasingly used for intact (33% to 78% of annual cases; $P < .001$) as well as ruptured AAA repair (5% to 28%; $P < .001$). The proportion of intact open repairs performed by VSs increased from 52% to 65% ($P < .001$), whereas for EVAR, the proportion went from 60% to 67% ($P < .001$). The proportion performed by VSs increased for ruptured open repairs from 37% to 53% ($P < .001$) and for ruptured EVARs from 28% to 73% ($P < .001$). Compared with treatment by VSs, treatment by a CS (0.55 [0.53-0.56]) and GS (0.66 [0.64-0.68]) was associated with a decreased likelihood of undergoing endovascular rather than open AAA repair.**

Conclusions: **VSs are performing an increasing majority of AAA repairs, in large part driven by the increased utilization of EVAR for both intact and ruptured AAA repair. However, GSs and CSs still perform AAA repair. Further studies should examine the implications of these national trends on the outcome of AAA repair. (J Vasc Surg 2015;62:562-8.)**

During the late 20th century, surgery became a technology-driven profession.[1] Since then, innovations such as endoscopic and endovascular surgery have transformed clinical medicine. Besides changing the procedure itself, these disruptive technologies have had their effect on the type of physicians performing the procedures. Percutaneous coronary intervention, for example, has diminished the proportion of coronary revascularizations performed by cardiac surgeons (CSs), whereas the proportion of interventional cardiologists (ICs) increased dramatically with the use of this technique.[2] For abdominal aortic aneurysm (AAA) repair, it is unclear how the introduction and widespread adoption of endovascular aneurysm repair (EVAR) have changed the distribution of specialties performing elective and ruptured AAA repair.

Before the introduction of EVAR, open surgical repair was the primary method of treatment. Using Medicare data, Birkmeyer et al[3] showed that between 1998 and 1999, before the widespread adoption of EVAR, vascular surgeons (VSs) performed 39% of all elective AAA repairs, whereas CSs and general surgeons (GSs) performed 33% and 28%, respectively. In contrast to elective AAA repair, GSs performed the largest proportion of ruptured AAA repairs at 39%, followed by VSs at 33% and CSs at 29%.[4] Currently, as with coronary revascularization, the endovascular approach has also led to the inclusion of nonsurgical specialists in treating patients with AAA, such as ICs and interventional radiologists (IRs). Because the performance of EVAR requires a specific skill set that has not been mastered by many surgeons from other specialties, we hypothesize that the proportion of surgical specialists other than VSs (ie, GSs and CSs) has declined, whereas VSs, IRs, and ICs are responsible for an increasing number of patients because of a shift from open repair toward EVAR.

The purpose of this study was to analyze how the introduction of EVAR has influenced which specialties are

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providing care for AAA patients for both elective and ruptured AAA repair in the United States.

METHODS

Database. The Nationwide Inpatient Sample (NIS) is the largest national administrative database and represents a 20% sample of all payer (insured and uninsured) hospitalizations. The NIS is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. Years 2001 to 2009 were queried using International Classification of Diseases, Ninth Revision (ICD-9) codes to identify patients with diagnosis codes for intact (ie, elective, symptomatic, and mycotic aneurysms) AAA (441.4) and ruptured AAA (441.3). ICD-9 coding does not distinguish infrarenal from juxtarenal or suprarenal AAA. More recent years could not be interrogated because of discontinuation of the surgeon identification variables in the NIS database after 2009.[5] Patients who underwent open AAA repair (38.44, 39.25) or EVAR (39.71) were selected. Patients with procedural codes for both open repair and EVAR were considered to have undergone EVAR as they likely represent conversions to open repair. Patients with ICD-9 codes for a thoracic aneurysm (441.1 or 441.2), thoracoabdominal aneurysm (441.6 or 441.7), or aortic dissection (441.00-441.03) were excluded. As the NIS contains de-identified data only without protected health information, Institutional Review Board approval and patient consent were waived.

The primary outcome was proportional procedure volume by physician specialty over time for intact and ruptured AAA repair. We evaluated the uptake of EVAR overall and by specialty over time. In addition, we assessed the likelihood of receiving EVAR rather than open repair by specialty.

Physician specialty. For AAA repair, we were interested in the following types of physicians: VSs, GSs, CSs, ICs, and IRs. The NIS provides unique physician identifiers per state that allow tracking of procedures performed by that physician during that specific year in that state. Of the available states, 27 provide two unique physician identifiers, with 22 of the 27 specifically detailing which physician performed the primary procedure (Supplementary Table I, online only). For the remaining five states, the identifiers were used only when both identifiers were the same to ensure that the identified physician was the one performing the primary procedure. We composed a list of specific procedures (Supplementary Table II, online only) that we used to determine the specialty of each physician (VS, GS, CS, IC, or IR). The top 15 procedures identified for each of the physician specialties are listed in Supplementary Table III, online only. Similar approaches have been previously reported.[6-8] Subsequently, a hierarchical model was created: each physician who performed >10 cardiac surgery procedures was labeled a CS; the remaining physicians who performed >10 interventional cardiology procedures (eg, coronary stenting) were labeled ICs; physicians with >10 interventional radiology procedures not typically performed by VSs (eg, liver biopsy, nephrostomy) were identified as IRs; the remaining physicians whose procedures consisted of 75% to 100% of vascular procedures with >10 in number were classified as VSs; physicians whose procedures consisted of 0% to 75% of vascular procedures and performed >10 general surgery procedures were classified as GSs. Similar approaches have been previously described.[9,10] Of the procedures labeled as open repairs, 210 were coded as being performed by ICs or IRs (0.1% of total procedures). We thought these were most likely miscoded endovascular procedures and excluded these patients from further analyses.

Statistical approach. Mean and standard deviation are reported for parametric data. Baseline variables were compared by χ^2 tests or *t*-tests, where appropriate. We examined the proportional volume of open AAA repairs and EVAR for each specialty and how this changed during the study period. Trends over time were assessed by the Cochran-Armitage test for trend. A P value $< .05$ indicates that annual procedural volumes followed a significant upward or downward (ie, nonrandom) trend over time. Multivariable logistic regression analysis was conducted to examine the influence of physician specialty type on the type of procedure performed, whether open or endovascular. Analyses were considered statistically significant when $P < .05$. Statistical analyses were performed with SAS 9.2 software (SAS Institute, Cary, NC) and SPSS Statistics 21 (IBM Inc, Chicago, Ill).

RESULTS

Overall, 108,587 EVARs and 85,080 open AAA repairs were identified in the study period, of which 3011 EVARs and 12,811 open repairs were for ruptured AAA. The annual overall volume increased from 20,134 in 2001 to 22,541 in 2009 ($P < .001$). Characteristics of the patients and hospitals are detailed in Table I. Of all AAA repairs, 61% of AAA repairs were performed by VSs, 20% by GSs, and 16% by CSs, whereas the remainder were performed by ICs and IRs (3% combined). Fig 1 illustrates changes over time for each physician specialty. VSs performed an increasing proportion of AAA repairs during the study period (52% in 2001 to 66% in 2009; $P < .001$; Supplementary Table IV, online only). During the same period, GSs and CSs performed fewer repairs (25% to 17% [$P < .001$] and 19% to 13% [$P < .001$], respectively). Similarly, the absolute number of VSs performing AAA repair increased 30% during the study period, whereas the number of GSs and CSs decreased over time (46% and 30%, respectively).

Intact AAA repair. With 55%, VSs performed the majority of open AAA repairs (increasing from 52% to 65% from 2001 to 2009; $P < .001$). During this same period, GSs performed 24% of all intact open repairs (decreasing from 25% to 16%; $P < .001$), followed by CSs with 22% of cases (24% to 19%; $P < .001$; Fig 2, *A*). VSs also performed the majority of EVARs at 67% (increasing from 60% to 67% from 2001 to 2009), followed by 16% performed by GSs (19% to 17%; $P < .001$), 13% by CSs (10.5% to 11.3%; $P = .009$), and 4% by ICs and IRs