

From the Western Vascular Society

Morbidity of endovascular abdominal aortic aneurysm repair is directly related to diameter

Douglas M. Overbey, MD,^{a,b} Natalia O. Glebova, MD, PhD,^a Brandon C. Chapman, MD,^a Patrick W. Hosokawa, MS,^c John C. Eun, MD,^{a,b} and Mark R. Nehler, MD,^a Aurora, Colo

ABSTRACT

Objective: Previous randomized controlled trials have defined specific size thresholds to guide surgical decision-making in patients presenting with an abdominal aortic aneurysm (AAA). With recent advances in endovascular techniques, the anatomic considerations of AAA repair are rapidly changing. Our specific aims were to evaluate the most recent national population data to compare anatomic differences and perioperative outcomes in patients with AAA.

Methods: The American College of Surgeons National Surgical Quality Improvement Program was queried from 2011 to 2015 using the targeted vascular public use file. Patients with AAA undergoing elective open or endovascular repair were included. Risk factors and outcomes were stratified by size and divided into quartiles for categorical comparison. A logistic regression model was used to compare the impact of size on morbidity and mortality with each technique. A risk adjustment model used all preoperative criteria to generate observed and expected values for open and endovascular repair.

Results: There were 10,026 patients who underwent elective AAA repair, 8182 (81.6%) endovascular and 1844 (18.4%) open. Repairs were divided into density quartiles for a logistic analysis: smallest quartile, 3.5 to 5 cm; second quartile, 5.01 to 5.5 cm; third quartile, 5.51 to 6.2 cm; and largest quartile, >6.2 cm. Patients with larger aneurysms (>6.2 cm) were more likely to be male, to have a dependent functional status, and to have increased blood urea nitrogen concentration and American Society of Anesthesiologists score ($P < .05$). Larger aneurysms had longer operative time (162 vs 135 minutes) and greater extension toward the renal and iliac vessels (all $P < .05$). Risk adjustment revealed an observed/expected morbidity plot that favored endovascular repair throughout the size range but confirmed lack of size effect within the open repair category. The adjusted increase in morbidity with endovascular repair is 9.7% per centimeter increase in size of AAA. These trends remained true with an infrarenal subgroup analysis.

Conclusions: Patients with a larger AAA have comorbidities and anatomic factors associated with a more difficult repair. The higher morbidity seen with larger aneurysms represents both anatomic and patient factors but seems to have a greater impact on endovascular repairs. However, endovascular repair still results in fewer near-term complications than open repair across all size strata. (J Vasc Surg 2017;■:1-11.)

Abdominal aortic aneurysm (AAA) diameter is the strongest known predictor of rupture.¹⁻⁵ Thus, size is used as a major form of anatomic guidance for repair in asymptomatic patients. Previous randomized controlled trials including the UK Small Aneurysm Trial and the Aneurysm Detection and Management (ADAM) trial helped define 5.5 cm as the inflection point at which

the risk of rupture outweighs the risk of repair.^{1,5} This size cutoff was subsequently confirmed by meta-analyses showing long-term survival to be indifferent below this size threshold.⁶

However, these level I data were obtained in the setting of 2.7% to 5.8% perioperative mortality. With recent advances in endovascular repair, current perioperative mortality estimates are as low as 1.6% for endovascular aneurysm repair (EVAR) and 4.2% for open repair.^{7,8} Guidelines from major societies generally recommend repair above 5.5 cm in an average male patient and >5.0 cm for women, with the discretion of the physician and patient below that diameter.⁹ Recent studies (including the current study) indicate that the median diameter of all AAA repairs in the United States is likely to be between 5.4 cm (5.4 cm for EVAR and 5.7 cm for open repair) using VQI data and 5.5 cm (5.5 cm for EVAR and 5.8 cm for open repair) using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) data,¹⁰ demonstrating a large volume of elective AAA repair occurring by discretion because 42% to 50% of repairs are performed at sizes <5.5 cm.

From the Division of Vascular Surgery and Endovascular Therapy, Department of Surgery, University of Colorado^a; the Department of Surgery, VA Eastern Colorado HealthCare System^b; and the Adult and Child Consortium for Health Outcomes Research and Delivery Science (ACCORDS).^c

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Correspondence: Mark R. Nehler, MD, Michael Dunaway Professor of Surgery, Vascular Surgery Division Chief, Mail Stop C312, 12631 E 17th Ave, Rm 5419, Aurora, CO 80045 (e-mail: mark.nehler@ucdenver.edu).

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Comparisons between open and endovascular techniques have been extensive, with level I data stemming from the Dutch Randomized Endovascular Aneurysm Management (DREAM) trial, EVAR 1 trial, Open Versus Endovascular Repair (OVER) trial, and Aneurysme de l'aorte abdominale: Chirurgie versus Endoprothese (ACE) trial.¹¹⁻¹⁴ All trials indicated a reduced perioperative morbidity and mortality in favor of endovascular repair, highlighting the major benefit of EVAR in short-term outcomes. The Positive Impact of Endovascular Options for Treating Aneurysms Early (PIVOTAL) and Comparison of Surveillance Versus Aortic Endografting for Small Aneurysm Repair (CAESAR) randomized trials were designed to determine if repair of smaller aneurysms (4-5 cm in PIVOTAL and 4.1-5.4 cm in CAESAR) was superior to surveillance alone, and both trials found no discernible benefit to earlier repair at smaller sizes.^{15,16}

Notable advancements have been made in endovascular techniques for complex anatomic considerations, expanding indications for EVAR, composed of both on- and off-label techniques. Differences in EVAR outcomes (such as type I endoleaks, device migration, secondary intervention, and open conversion) have been reported as higher for larger diameter aneurysms, and mortality is also higher.^{17,18} However, these studies are a decade old, and more recent data on the effects of aneurysm size on EVAR and open outcomes are lacking.

It is intuitive that as AAAs increase in diameter, factors complicating EVAR also increase. These factors would include tortuous and aneurysmal iliacs, changes in the AAA neck (tortuosity and dilation), and more advanced comorbidities of the patients with age. Anatomic issues have been confirmed in small AAA populations using multidimensional growth measurements, indicating that the neck shortens and angulation increases as aneurysms enlarge.¹⁹ Larger AAAs are also associated with thicker intraluminal thrombus and pronounced elastin loss, relating to the propensity for rupture.²⁰

With almost half of aneurysm repair interventions fitting outside of level I indications as well as with changing procedural mortality rates, expanding indications and off-label use of endovascular options, and improvements in medical management of cardiovascular comorbidities, is earlier repair of smaller diameter aneurysms justified?²¹ Our goal was to evaluate the most recent national population data comparing anatomic differences and perioperative outcomes in patients across all size strata, with a specific aim to determine if there is a morbidity and mortality advantage to repair of aneurysms at a smaller size.

METHODS

The primary hypothesis was that AAA repair in both open repair and EVAR would have worse outcomes with larger diameter AAAs for the reasons outlined before.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected National Surgical Quality Improvement Program data
- **Take Home Message:** Increasing aortic aneurysm size was associated with increased morbidity after 8182 endovascular aneurysm repairs but not after 1844 open repairs.
- **Recommendation:** The authors suggest performing endovascular aneurysm repair at smaller aneurysm diameters on the basis of a lower 30-day morbidity identified in their study.

Database. The ACS NSQIP is a nationally validated, risk-adjusted data set comprising major surgical procedures and 30-day outcomes (<https://www.facs.org/quality-programs/acs-nsqip/about>).²² This database has more recently included data sets specific to certain specialties, such as the Targeted Vascular module. This data set links to the original Participant Use Data File and includes preoperative, operative, and postoperative variables including AAA-specific variables, such as diameter, branch revascularization, and operation-specific outcomes. Diameter measurements in this data set are the maximum measured by either computed tomography or ultrasound. The Colorado Multiple Institutional Review Board has waived the need for approval to use deidentified data for this study, and as such no informed consent was required or obtained.

Study population. The ACS NSQIP Participant Use Data File was queried from 2011 to 2015 for patients with AAA undergoing open or endovascular repair, as dictated by the targeted public use files. These patients were linked with corresponding variables in the public use files, yielding 12,545 potential AAA cases (Fig 1). Emergent operations and cases missing AAA diameter data were excluded to yield the overall study cohort. Diameters <3.5 cm were also excluded because there were likely additional anatomic considerations outside of aneurysm alone (ie, iliac aneurysm) prompting repair. The overall study cohort was broken down further into open repair vs EVAR. Further stratification based on AAA diameter quartiles was selected in a patient density fashion, with diameter selected to the hundredths decimal available in this data set.

Demographics and preoperative and outcome variables. After dividing into quartiles, we compared all variables tracked in the NSQIP, including standard demographic data, preoperative patient factors, intraoperative variables, and outcomes. Variables generalized to the entire NSQIP data set and those specific to the open AAA and EVAR targeted data sets were included. Relevant variables specific to the AAA targeted data set

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