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Association for Academic Surgery

Mortality after endovascular *versus* open repair of abdominal aortic aneurysm in the elderly

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ARTICLE INFO

Article history:
Received 6 January 2017
Received in revised form
22 February 2017
Accepted 30 March 2017
Available online 7 April 2017

Keywords:
Abdominal aortic aneurysm
Nonruptured aneurysm
Vascular surgery
Open *versus* endovascular repair
NSQIP
Mortality

ABSTRACT

Background: Age is a well-known risk factor for postoperative death in patients with abdominal aortic aneurysms (AAA), and the efficacy of open aneurysm repair (OAR) and endovascular aneurysm repair (EVAR) remains controversial in the elderly population. The aim of this study was to determine the predictors of 30-d mortality after AAA repair in elderly population.

Methods: Using the National Surgical Quality Improvement Program vascular-targeted database (2011-2014), we identified all patients aged >70 y who underwent OAR and EVAR for nonruptured AAA. Univariate and multivariable logistic regression analyses were implemented to examine postoperative mortality adjusting for patient demographics and characteristics.

Results: A total of 4229 nonruptured AAA repairs were performed (OAR: 360 [8.5%] *versus* EVAR: 3869 [91.5%]). Most patients were males (79 %) and White (81%) with a mean age of 78 ± 6 y. Obesity was more prevalent in EVAR group (31% *versus* 24%, $P = 0.008$). Whereas, smoking was more likely to be seen in patients undergoing an OAR (35% *versus* 22%, $P < 0.001$). The 30-d mortality was significantly higher after OAR *versus* EVAR (8% *versus* 2%, $P < 0.001$). After adjusting, OAR was associated with almost five times higher mortality than EVAR (adjusted odds ratio: 4.88; 2.85-8.34, $P < 0.001$).

Conclusions: This study reflects contemporary real world outcomes of nonruptured AAA repair in the elderly. Open repair was associated with almost fivefold increase in mortality compared with endovascular repair. Elderly patients who are functionally dependent are less likely to benefit from AAA repair, whether OAR or EVAR. Further prospective studies are required to better understand the predictors of mortality after AAA repair in the geriatric population which could guide decision-making and improve outcomes in this population.

Introduction

In the United States, 45,000 patients with intact abdominal aortic aneurysm (AAA) undergo elective repair, resulting in 1400 perioperative deaths per year.[1] Several meta-analyses and prospective randomized controlled trials (RCTs) including the Dutch Randomized Endovascular Aneurysm Management (DREAM),[2] the United Kingdom Endovascular

Presented at 12th Annual Academic Surgical Congress (ASC) for Vascular Quick Shot session, February 2017, Las Vegas, NV.
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0022-4804/$ – see front matter © 2017 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jss.2017.03.061

Aneurysm Repair 1 (EVAR-1),[3] and the Open *versus* Endovascular Repair (OVER)[1] studies have displayed favorable perioperative outcomes after endovascular aneurysm repair (EVAR) compared with open aneurysm repair (OAR).[4,5] However, the early survival advantage of EVAR seems to be lost within 2 y leaving uncertainty about the preferred method for AAA repair.[6-10]

Age is well-known risk factor for postoperative death after AAA repairs[11]; however, the efficacy of these repairs in the elderly remains controversial. A recent study from our group demonstrated significantly higher mortality in octogenarians undergoing OAR or EVAR compared with nonoctogenarians.[12] Using the most recent National Surgical Quality Improvement Program (NSQIP) data from 2011 to 2014, this study aims to look at the predictors of 30-d postoperative mortality after undergoing AAA repair in the elderly population of the United States. This will help care providers to provide elderly patients with better estimates of the risk–benefit ratio of aneurysm repair and help guide clinical decision-making.

Methods

The John Hopkins Institution's Research Board approved this study and the need for consent was waived. A retrospective study of the American College of Surgeons–National Surgical Quality Improvement Program (ACS-NSQIP) Vascular-targeted participant use data file was performed. ACS-NSQIP Vascular is a peer-evaluated national database that includes specific vascular surgery–related variables such as the proximal and distal extents of the aneurysm, specific operative characteristics, and 30-d postoperative vascular outcomes in both inpatient and outpatient settings.[13] The selected cohort was later merged with general NSQIP participant use data file to attain additional information on patient's demographics and comorbidities.

All patients from 2011 to 2014 undergoing OAR and EVAR were identified. Only patients aged ≥70 y with a diagnosis of intact infrarenal AAA were included (Appendix Table A for inclusion and exclusion criteria based on indication of surgery). The clinical variables are further defined in the NSQIP user guide.[13]

Patients' demographics, comorbidities, and operative characteristics were collected and compared between the two surgical approaches (OAR *versus* EVAR). The demographic variables included age, gender, obesity (body mass index >30), smoking history, functional dependency, admitted location, and American Society of Anesthesiologists classifications >3. Multiple comorbidities were identified: diabetes, hypertension, history of chronic obstructive pulmonary disease (COPD), history of congestive heart failure (CHF), steroid use, bleeding disorders, and renal failure with dialysis. Progressive renal insufficiency was determined by calculating glomerular filtration rate using the Modification of Diet in Renal Disease Study equation. Patient's operative and hospital characteristics included transfusion (preoperative transfusion of ≥1 unit of whole or packed red blood cells in 72 h before surgery), operative time in minute, length of stay (LOS) in days, and return to operation room. Finally, the aneurysm characteristics included diameter of the aneurysm in centimeters and extent of the aneurysm (distal) that are described in Table.

Primary outcome of the study was mortality within 30 d. Secondary outcomes included neurologic (stroke and coma more than 24 h), cardiac (cardiac arrest and myocardial infarction), renal (occurrence of acute renal failure and progressive renal insufficiency), pulmonary (pneumonia, pulmonary embolism, unplanned intubation, and ventilator support more than 48 h), and wound (superficial infection, deep infection, dehiscence, and organ space surgical site infections) complications (Fig. 1).

The statistical tests used to analyze categorical and continuous variables between the two surgical approaches were chi-squared test and Student's *t*-tests, respectively. Univariate and multivariate logistic regression analyses were implemented to examine mortality within 30 d using the following selected variables: surgery type (OAR *versus* EVAR), age, gender, race, body mass index > 30, smoking, dependency status, admitted location, COPD, CHF, hypertension requiring medications, steroid use, bleeding disorders, renal failure with dialysis, chronic renal insufficiency, transfusion, aneurysm diameter, and distal extent of the aneurysm. The significance value was established at P value < 0.05, and the final model was evaluated by Hosmer–Lemeshow goodness-of-fit test and area under the curve.

Results

A total of 4229 nonruptured AAA repairs were identified in patients aged >70 y. Of those, 3869 (91.5%) underwent EVAR, whereas 360 (8.5%) patients underwent OAR. A trend was noticed with significantly higher proportion of patients undergoing EVAR *versus* OAR from 2011 to 2014 ($P < 0.001$; Fig. 2).

Patient demographics and comorbidities

In our cohort, patients undergoing EVAR were older than OAR (78.4 ± 5.6 *versus* 76.8 ± 4.8, $P < 0.001$). There were more females in the OAR group (31.1% *versus* 20.6%, $P < 0.001$). Obesity (30.5% *versus* 23.9%, $P = 0.008$) was more prevalent in patients undergoing EVAR. In contrast, history of smoking was commonly seen in patients undergoing OAR (35.0% *versus* 22.3%, $P < 0.001$).

Operative and aneurysm characteristics

Mean operative time (236.3 ± 110.9 *versus* 146.3 ± 72.9 min) and LOS (9.8 ± 8.0 *versus* 3.1 ± 4.7 d) were significantly longer for OAR (both $P < 0.001$). OAR patients were also more likely to have a larger aneurysm diameter (6.3 ± 1.4 *versus* 5.8 ± 1.7 cm, $P < 0.001$) and return to operation room (9.4% *versus* 4.3%, $P < 0.001$) than EVAR. In patients undergoing endovascular repair, 24 (0.62%) had an acute conversion to open repair. Of 3869 endovascular repairs, 177 patients (4.6%) had a renal stent inserted.