From the Vascular and Endovascular Surgery Society

Intensive care unit admission after endovascular aortic aneurysm repair is primarily determined by hospital factors, adds significant cost, and is often unnecessary

Caitlin W. Hicks, MD, MS,[a] Husain N. Alshaikh, MD,[b] Devin Zarkowsky, MD,[c] Ian C. Bostock, MD,[d] Besma Nejim, MD, MPH,[a] *and* Mahmoud B. Malas, MD, MHS,[a] *Baltimore, Md; San Francisco, Calif; and Lebanon, NH*

ABSTRACT

Background: A large proportion of endovascular aortic aneurysm repair (EVAR) patients are routinely admitted to the intensive care unit (ICU) for postoperative observation. In this study, we aimed to describe the factors associated with ICU admission after EVAR and to compare the outcomes and costs associated with ICU vs non-ICU observation.

Methods: All patients undergoing elective infrarenal EVAR in the Premier database (2009-2015) were included. Patients were stratified as ICU vs non-ICU admission according to location on postoperative day 0. Both patient-level (sociodemographics, comorbidities) and hospital-level (teaching status, hospital size, geographic location) factors were analyzed using univariate and multivariable logistic regression to determine factors associated with ICU vs non-ICU admission. Overall outcomes and hospital costs were compared between groups.

Results: Overall, 8359 patients underwent elective EVAR during the study period, including 4791 (57.3%) ICU and 3568 (42.7%) non-ICU admissions. Patients admitted to ICU were more frequently nonwhite and had more comorbidities, including congestive heart failure, coronary artery disease, chronic kidney disease, chronic obstructive pulmonary disease, diabetes, and hypertension, than non-ICU patients (all, $P < .03$). ICU admissions were more common in small (<300 beds), urban, and nonteaching hospitals and varied greatly depending on surgeon specialty and geographic region ($P < .001$). A pattern emerged when admission location was clustered by hospital; ICU patients were treated at hospitals where 96.7% (interquartile range, 84.5%-98.9%) of patients were admitted to ICU after EVAR, whereas non-ICU patients were treated at hospitals where only 7.5% (interquartile range, 4.9%-25.8%) were admitted to ICU after EVAR. A multivariable logistic regression model accounting for patient-, operative-, and hospital-level differences had a significantly lower area under the curve for predicting ICU admission after EVAR than a model accounting only for hospital factors (area under the curve, 0.76 vs 0.95; $P < .001$). The overall rate of adverse events was higher for ICU vs non-ICU patients (16.3% vs 13.7%; $P < .001$). Failure to rescue (2.9% vs 3.9%; $P = .42$) and in-hospital mortality (0.4% vs 0.4%; $P = .81$) were similar between groups. After adjusting for patient and hospital factors as well as for postoperative adverse events, ICU admission after EVAR cost $1475 (95% confidence interval, $768-2183) more than non-ICU admission ($P < .001$).

Conclusions: Among patients undergoing elective EVAR, postoperative ICU admission is more closely associated with hospital practice patterns than with individual patient risk. Routine ICU admission after EVAR adds significant cost without reducing failure to rescue or in-hospital mortality. (J Vasc Surg 2018;67:1091-101.)

Recent reports suggest that endovascular aortic aneurysm repair (EVAR) is associated with a perioperative mortality of approximately 1.6% compared with 5.2% for open repair.[1] Several reports demonstrate that EVAR is well tolerated by fragile, elderly patients with multiple comorbidities.[2-5] Consequently, EVAR has surpassed open repair as the most common treatment for abdominal aortic aneurysm (AAA).[6,7]

One issue associated with the increasing prevalence of EVAR is the associated cost of the operation.[3,8-10] Costs for elective EVAR have been reported to be up to 34% higher than the costs associated with open AAA repair, despite the shorter lengths of hospital stay associated with EVAR.[9] Procedural costs, particularly the endograft, account for a significant proportion of the initial overhead.[3,11] Care pathways, including postoperative disposition, also play a role.[9,12] A comprehensive EVAR delivery redesign paradigm focusing on eliminating

From the Division of Vascular Surgery and Endovascular Therapy, Johns Hopkins Medical Institutes,[a] and The Johns Hopkins Surgery Center for Outcomes Research, Johns Hopkins School of Medicine,[b] Baltimore; the Division of Vascular and Endovascular Surgery, University of California San Francisco, San Francisco[c]; and the Division of Vascular and Endovascular Surgery, Dartmouth-Hitchcock Medical Center, Lebanon.[d]

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Correspondence: Mahmoud B. Malas, MD, MHS, Director of the Center for Research Excellence and Surgical Trials, Johns Hopkins Medical Institutions, 4940 Eastern Ave, A 547, Baltimore, MD 21401 (e-mail: bmalas1@jhmi.edu).

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waste associated with perioperative services and clinic visits has been shown to reduce cost while preserving quality of care.[12] As such, there is a recent interest in methods of cost reduction for EVAR.

Streamlined perioperative care pathways targeted at clinic visits, instrument use, and imaging protocols have previously been shown to reduce cost for EVAR.[12] However, institutional overhead associated with the procedure remains significant.[11] One means by which these expenses could be reduced is to lower the acuity of postoperative care necessary for post-EVAR patients. One of the benefits of EVAR over open AAA repair is the minimally invasive nature of the procedure that leads to faster recovery of the patient and shorter lengths of stay.[8,10] A number of groups have even suggested that outpatient EVAR is feasible and safe in some patients.[13,14] Some surgeons, however, routinely admit EVAR patients to the intensive care unit (ICU) for observation postoperatively. In this study, we aimed to describe the factors associated with ICU admission after EVAR and to compare the outcomes and costs associated with ICU vs non-ICU observation.

METHODS

Data source. All patients undergoing elective infrarenal EVAR in the Premier Healthcare Database (PHD) between July 1, 2009, and March 31, 2015, were included in the analysis. The PHD is a Health Insurance Portability and Accountability Act-compliant, U.S. hospital-based, geographically diverse, all-payer database that contains information on 5 million inpatient discharges per year, representing approximately 20% of annual U.S. inpatient discharge.[15] Hospital participation in the PHD is voluntary, and a complete inpatient census is collected from participating hospitals. Patients can be tracked across the inpatient setting, with data available by day of stay. The PHD provides information on patient demographics, hospital and visit characteristics, and comprehensive billing and financial data. As such, it is one of the largest national databases to provide data on both patient outcomes and cost-related data. The Johns Hopkins Institutional Review Board approved this study. Informed consent was waived as the data were deidentified and obtained from a publicly available database.

Selection criteria and study cohort. All patients who were primarily admitted for intact (unruptured) AAA in the PHD were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnosis code 441.4 (n = 44,744). Patients who were managed medically and those who underwent open repair (ICD-9-CM procedure codes 38.34, 38.36, 38.44, 38.64, 39.25, and 39.52), underwent endovascular repair with open conversion (ICD-9-CM procedure code 39.71), had multiple endovascular repairs during the hospitalization, or had a previous record of endovascular repair were excluded from analysis (n = 14,898). We also excluded patients with noninfrarenal aortic aneurysms (n = 15,307), nonelective admissions (n = 4170), admission to a stepdown unit on postoperative day 0 (POD 0; n = 1202), transfer in from another facility (n = 580), and missing hospital or ward disposition (n = 228).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected data from the Premier database
- **Take Home Message:** After 8359 elective endovascular aortic aneurysm repairs, 57.3% of the patients were treated in the intensive care unit (ICU) and 42.7% in the ward. ICU care was more expensive, but there was no difference in adverse events, failure to rescue, and in-hospital mortality.
- **Recommendation:** This study suggests that routine ICU admission after endovascular aortic aneurysm repair is unnecessary and more expensive, and it is generally dictated by hospital practice patterns rather than by patient factors.

Definition of variables. Patients were classified as non-ICU or ICU admission on the basis of their immediate postoperative destination. Therefore, patients who were initially on the general ward/floor and subsequently transferred to the ICU were classified as non-ICU patients. We collected baseline demographics (age, gender, race, insurance status) and comorbidity data (congestive heart failure, coronary artery disease, chronic kidney disease, end-stage renal disease, chronic obstructive pulmonary disease [COPD], diabetes, and hypertension) for all patients. Charlson Comorbidity Index was categorized into three groups: 0-1, 2, and ≥3.[16] We also collected hospital-level data, including urban vs rural location (defined by PHD according to U.S. Census definitions), teaching status, census divisions, bed size, and hospital volume (defined as the number of admissions for AAA per hospital per year). Technical details including operating physician specialty, operating room time (in hours), and need for perioperative transfusion (defined as transfusion of blood, plasma, or platelets during or after surgery) were also recorded. Physician specialty was determined on the basis of self-reporting; board certification was not verified. Operating room time was reported as estimated operating room time, which is a composite variable of operating room time and anesthesia time (which was substituted in observations for which the value of operating room time value was missing; n = 1642).

Study groups and outcomes definitions. This study is composed of a two-stage analysis. The first stage aimed