Laparotomy during endovascular repair of ruptured abdominal aortic aneurysms increases mortality

Shaunak S. Adkar, BA,[a] Ryan S. Turley, MD,[b] Ehsan Benrashid, MD,[b] Mitchell W. Cox, MD,[b] Leila Mureebe, MD,[b] and Cynthia K. Shortell, MD,[b] *Durham, NC*

Objective: **Subset analyses from small case series suggest patients requiring laparotomy during endovascular repair of ruptured abdominal aortic aneurysms (REVAR) have worse survival than those undergoing REVAR without laparotomy. Most concomitant laparotomies are performed for abdominal compartment syndrome. This study used data from the American College of Surgeons National Surgical Quality Improvement Program to determine whether the need for laparotomy during REVAR is associated with increased mortality.**

Methods: **Data were obtained from the 2005 to 2013 National Surgical Quality Improvement Program participant user files based on Current Procedural Terminology (American Medical Association, Chicago, Ill) and International Classification of Diseases-9 Edition coding. Patient and procedure-related characteristics and 30-day postoperative outcomes were compared using Pearson χ^2 tests for categoric variables and Wilcoxon rank sum tests for continuous variables. A backward-stepwise multivariable logistic regression model was used to identify patient- and procedure-related factors associated with increased death after REVAR.**

Results: **We identified 1241 patients who underwent REVAR, and 91 (7.3%) required concomitant laparotomy. The 30-day mortality was 60% in the laparotomy group and 21% in the standard REVAR group ($P < .001$). The major complication rate was also higher in the laparotomy group (88% vs 63%; $P < .001$). Multivariable analysis showed laparotomy was strongly associated with 30-day mortality (odds ratio, 5.91; 95% confidence interval, 3.62-9.62; $P < .001$).**

Conclusions: **Laparotomy during REVAR is a commonly used technique for the management of elevated intra-abdominal pressure and abdominal compartment syndrome development. The results of this study strongly confirm findings from smaller studies that the need for laparotomy during REVAR is associated with significantly worse 30-day survival. (J Vasc Surg 2016;■:1-6.)**

Endovascular repair for ruptured abdominal aortic aneurysms (REVAR) is an increasingly used technique for emergency management in patients with appropriate anatomy.[1,2] Given that patients treated with REVAR often require aggressive fluid resuscitation and are inherently spared a laparotomy incision, they are vulnerable to developing abdominal compartment syndrome (ACS),[3] defined as intra-abdominal pressure (IAP) >20 mm Hg or abdominal perfusion pressure <60 mm Hg with end-organ failure. Indeed, the current body of literature suggests that ACS is an often fatal complication in the period after REVAR and that mortality is increased when ACS develops after REVAR as opposed to after open repair.[4]

Decompressive laparotomy is the operative treatment for patients who develop ACS; however, whether the need for decompressive laparotomy during REVAR truly affects survival remains unclear.[5] Previous studies assessing mortality associated with laparotomy after REVAR have been limited to subset analyses from small case series, resulting in highly variable quoted mortality rates ranging from 11% to 83%.[4,6] Furthermore, as REVAR continues to evolve as the preferred treatment for ruptured aneurysms, estimating the true incidence of laparotomy and identifying associated risk factors for its development may guide strategies to improve overall outcomes for REVAR.

Using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP), we identified 1241 patients undergoing REVAR during a 9-year period (2005-2013). Because concurrent laparotomy predominantly occurs in the setting of ACS development, we used concurrent laparotomy not performed for other indications as a surrogate metric for elevated IAP and ACS development. The primary objective of this study was to determine whether the need for laparotomy after REVAR is associated with increased 30-day mortality using data from the American College of Surgeons NSQIP. Our secondary objective was to identify variables associated with need for laparotomy as a surrogate for ACS. The use of NSQIP data provides a large, audited, multicenter, "procedure-targeted" database that is well equipped to provide a larger sample size to address our primary and secondary aims.

METHODS

The NSQIP is an independently audited and validated clinical database that contains patient demographic and procedure-related data on >500,000 general

From the Duke University School of Medicine[a]; and the Department of Surgery, Duke University Medical Center.[b]

Author conflict of interest: none.

Correspondence: Ryan S. Turley, MD, Department of Surgery, Duke University Medical Center, 2301 Erwin Rd, 7th Flr, HAFS Bldg, Durham, NC 27710 (e-mail: ryan.turley@dm.duke.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2016.04.051

and subspecialty procedures at nearly 374 participating academic and community hospitals in the United States. NSQIP uses a systematic sampling system across participating institutions to prospectively retrieve data on patient demographics, comorbid illnesses, perioperative variables, and 30-day postoperative mortality. Because this was a retrospective study with no patient-identifiable data, IRB approval was waived, and patient informed consent was not obtained.

For these analyses, we identified and included data from patients undergoing REVAR using the Current Procedure Terminology (CPT; American Medical Association, Chicago, Ill) diagnosis codes from the 2005 to 2011 and the 2011 to 2013 NSQIP data sets, which yielded 1248 patients for analysis. Patients treated with REVAR were identified using CPT codes 34800, 34802, 34803, 34804, and 34805 for endovascular abdominal aortic aneurysm repair and concomitant International Classification of Diseases-9 Edition code of 441.3 indicating REVAR.

Patients with concurrent laparotomy were identified by searching NSQIP variables "concpt1-9" and "othercpt1-9" for CPT codes 35840, 49000, 49002, and 49010. Patients undergoing open repair after unsuccessful EVAR were identified and excluded by searching using NSQIP variables "concpt1-9"and "othercpt1-9" for CPT codes 34830, 34831, and 34832. Because the primary purpose of this study was to evaluate the need for laparotomy as a surrogate for ACS, we excluded seven patients who also had CPT codes with an indication for laparotomy other than ACS. These were primarily for intestinal ischemia, colonic ischemia, or incarcerated hernia, as denoted by CPT codes 44120, 44615, 44140, and 49561.

The primary outcome variables for this analysis were 30-day mortality and operative mortality, defined as death on the day of operation. Secondary outcome variables were 22 postoperative complication variables recorded by the NSQIP data set, among which are overall morbidity, major complication rate, length of stay, surgical site infections, prolonged ventilator dependence, and cardiac arrest.

Patient-specific preoperative characteristics and outcomes were compared for patients with and without concurrent laparotomy. Comparisons of patient- and procedure-related characteristics and 30-day postoperative outcomes by concurrent laparotomy were performed with Pearson χ^2 tests for categoric variables and Wilcoxon rank sum tests for continuous variables. To identify patient- and procedure-related variables that might serve as predictors for 30-day mortality, we constructed a backward-stepwise multivariable logistic regression model and set the probability of type I error of 0.1 as the significance level for exclusion from the model. Variables with missing values were excluded from the regression analysis. Specific definitions of these variables can be found in the NSQIP user file guide. Statistical analyses were performed with Stata 11.0 software (StataCorp LP, College Station, Tex).

RESULTS

Using the 2005 to 2013 merged NSQIP participant user files, we identified 1241 patients (77% male) who were treated with REVAR, with preoperative patient- and procedure-related variables reported in Table I. Patients were a median age of 75 years (interquartile range, 67-82 years). Common comorbidities included diabetes (14%), chronic obstructive pulmonary disease (19%), tobacco smoking (35%), and coronary artery disease (71%). The American Society of Anesthesiologists (ASA) Physical Status Classification was ≥III for 99% of the cohort.

Using the additional CPT codes recorded for each patient, we identified 91 patients (7%) who had a concurrent laparotomy who met our inclusion and exclusion criteria. Comparisons of patient characteristics and preoperative variables between treatment groups are reported in Table I. Although most demographic characteristics were similar in the two groups, there was a significantly lower incidence of smoking (24% vs 36%; $P < .05$) and coronary artery disease (55% vs 72%; $P < .01$) among patients requiring a concomitant laparotomy. However, patients who received a concurrent laparotomy more frequently required preoperative ventilation (26% vs 9%; $P < .001$) or preoperative transfusion of blood products (30% vs 16%; $P < .005$). Preoperative hemodynamic status varied with treatment group ($P < .05$), with an increased prevalence of shock (4% vs 2%) and systemic inflammatory response syndrome (35% vs 23%) in the group with concurrent laparotomy. Moreover, preoperative albumin varied by treatment group, with more patients having an abnormal serum albumin level (defined by 3.5-5.5 g/dL) in the laparotomy group (50% vs 37%; $P < .01$).

We next examined differences in outcomes stratified by treatment groups (Table II) to assess the association of laparotomy with other postoperative complications. Frequencies of 30-day mortality and operative mortality rose from 21% to 60% and 6% to 30%, respectively, in the laparotomy group ($P < .001$). Patients receiving concurrent laparotomy had significantly higher rates of overall morbidity (88% vs 64%; $P < .001$) and major complications (88% vs 63%; $P < .001$). Early return to the operating room was twice as common in patients undergoing laparotomy (34% vs 17%; $P < .001$), and median operative time was longer (166 vs 145 minutes; $P < .001$). Furthermore, frequency of wound dehiscence was higher in patients with laparotomy (4% vs 1%; $P < .01$). Cardiopulmonary complications were also higher in patients with laparotomy, with patients undergoing laparotomy more frequently developing pneumonia (18% vs 10%; $P < .001$), cardiac arrest (23% vs 6%; $P < .001$), and prolonged ventilator dependence (53% vs 19%; $P < .01$). Complications affecting hemodynamic status also were more prevalent in patients with laparotomy, as demonstrated by a higher incidence of postoperative bleeding requiring transfusion (67% vs 49%; $P < .001$) and postoperative sepsis (15% vs 5%; $P < .001$).

To identify potential predictors of 30-day mortality, we performed a backward-stepwise logistic regression (Table III). Strikingly, concurrent laparotomy resulted in nearly a sixfold increase in the likelihood of 30-day mortality (odds ratio [OR], 5.91; 95% confidence interval [CI], 3.62-9.62; $P < .001$). Similarly, although less pronounced than for