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Outcomes and risk factors of cardiac arrest after vascular surgery procedures

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Background: **Despite increased awareness of the value of discussing patients' goals of care, advance directives, and code status as part of the surgical informed consent process, the actual outcomes and risks of cardiopulmonary resuscitation (CPR) remain poorly defined among some subsets of surgical patients. Thus, in an effort to generate an evidence base for communication about shared decision making and informed consent for vascular surgery patients and their surrogates, we defined the incidence, risks, and outcomes of postoperative cardiac arrest after primary vascular surgery procedures.**

Methods: **The 2007 to 2010 National Surgical Quality Improvement Program data were queried to develop a multi-institutional database of patients undergoing vascular surgery (N = 123,581). Univariate analyses and multivariate logistic regression were used to identify crude and adjusted risk factors for postoperative cardiac arrest requiring CPR and to assess outcomes.**

Results: **Postoperative cardiac arrest requiring CPR was seen in 1234 of 123,581 patients (1.0%) after vascular surgery at a mean of 7.2 ± 2 days. The 30-day mortality was 73.4% compared with 2.7% among patients who did not arrest ($P < .001$). Of CPR survivors, 102 (12.1%) were still hospitalized at 30 days. Patient variables that were most predictive of postoperative cardiac arrest included dependent functional status (odds ratio [OR], 2.9; 95% confidence interval [CI], 2.3-3.6; $P < .001$), dialysis dependence (OR, 2.7; 95% CI, 2.3-3.2; $P < .001$), emergent case (OR, 2.2; 95% CI, 1.9-2.5; $P < .001$), and preoperative ventilator dependence (OR, 2.0; 95% CI, 1.5-2.7; $P < .001$). Procedures associated with the highest risk included thoracic aortic surgery (OR, 6.9; 95% CI, 4.8-9.9; $P < .001$), open abdominal procedures (OR, 3.7; 95% CI, 3.1-4.4; $P < .001$), axillary-femoral bypass (OR, 2.1; 95% CI, 1.3-3.2; $P = .001$), and peripheral embolectomy (OR, 1.5; 95% CI, 1.2-1.9; $P = .002$). At least one major complication preceded cardiac arrest in 47.7% of patients including sepsis (23.5%), renal failure (14.5%), and myocardial infarction (12.1%). Patients with do not resuscitate orders were significantly less likely to undergo CPR (OR, 0.59; 95% CI, 0.39-0.93; $P = .021$).**

Conclusions: **Patients undergoing vascular surgery who suffer a postoperative cardiac arrest frequently die in spite of receiving CPR; for those who survive, there is likely to be prolonged hospitalization and significant morbidity. These data provide an evidence base for discussing goals of care, advance directives, and code status with vascular surgery patients and their surrogates. Further research into how to best communicate risk, to elicit patient preferences, and to engage in shared decision making is needed. (J Vasc Surg 2015;61:197-202.)**

There has been increased emphasis on shared decision making and efforts to discuss code status, advance directives, and patients' goals of care as part of the surgical informed consent process.[1-3] Not only should surgical patients and their surrogates be informed of the risks, benefits, and complications of a particular procedure, but patients' preferences and goals of care should be explored and documented preoperatively both to guide surgeons as they determine a treatment course and, furthermore, to serve as an advance directive should a patient subsequently lose capacity. Unfortunately, there are few data to serve as an evidence base for communication regarding shared decision making and informed consent for vascular surgery patients and their surrogates. In particular, the outcomes and risks of cardiopulmonary resuscitation (CPR) remain poorly defined among patients undergoing vascular surgery.

Among all hospitalized patients in the United States, cardiac arrest occurs at a rate of 0.4%; less than 20% of these patients will survive this event.[4] Among all postoperative surgical patients, the rate of cardiac arrest requiring CPR is 0.5%, with a 30-day mortality of 70% across all surgical specialties.[5] Patients undergoing cardiac and vascular surgery are at highest risk for postoperative cardiac arrest; vascular surgery patients are frequently elderly, have a high burden of medical comorbidities, and are at high risk for morbidity and mortality should they suffer a postoperative cardiac arrest.[6,7]

Despite our knowledge that vascular surgery patients are at high risk, there are few data regarding the likelihood that CPR will be necessary for a particular patient or the expected outcome should it be required. This acts as a barrier

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to the informed consent and shared decision-making processes and places the surgeon at increased medical-legal risk.[8,9] Most significantly, however, it leaves patients and their surrogates without the data necessary to make an autonomous choice. Thus, in an effort to generate an evidence base for communication about shared decision making and informed consent for vascular surgery patients and their surrogates, we defined the incidence, risks, and outcomes of postoperative cardiac arrest after vascular surgery.

METHODS

Patient selection. The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) is a multicenter program using prospective data providing risk-adjusted outcomes for quality improvement. Details pertaining to data gathering, sampling, and structure of the Participant Use Data File have previously been reported.[10-13] There are more than 135 variables included documenting preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes for patients undergoing specific surgical procedures. We identified all patients undergoing vascular surgery procedures performed by vascular surgeons from 2007 to 2010 in the ACS NSQIP Participant Use Data Files (N = 123,581). Procedures were then grouped with other like procedures into categories. Institutional Review Board approval was obtained and patient consent was waived.

Variables and outcome definitions. A primary objective was to identify perioperative patient variables that could predict postoperative cardiac arrest requiring CPR. NSQIP has a separate outcome category for cardiac arrest requiring CPR and identifies on which postoperative day it occurred. There is no separate variable for cardiac arrest without CPR. Cardiac arrest described in this manuscript is only when CPR was performed. All complications captured by ACS NSQIP were recorded by affected organ system and severity. Complications included pulmonary complications, cardiac complication, worsening renal function or acute renal failure, neurologic complications, thromboembolism, sepsis, bleeding, urinary tract infections, and surgical site infections.

Demographic variables considered included age, sex, race, and smoking history. Preoperative functional status (independent, partially dependent, and totally dependent) assesses the patient's ability to perform activities of daily living before the operation. Body mass index was stratified into categories of normal weight, underweight, overweight, and obese.

Concomitant medical conditions included diabetes, severe chronic obstructive pulmonary disease, congestive heart failure in the 30 days before surgery, hypertension requiring medication, peripheral vascular disease requiring prior revascularization or amputation, altered mental status or impaired sensorium, regular steroid use in the 30 days before surgery, history of bleeding disorders or chronic anticoagulation, hemodialysis dependence, prior percutaneous coronary intervention, prior cardiac surgery, current angina or recent myocardial infarction, prior stroke with or without deficits, and presence of a wound or infection.

Statistical analysis. Categorical variables were compared by Pearson χ^2 tests. Distributions of continuous variables were compared by Wilcoxon rank sum tests. Variables were considered for inclusion in the multivariate model if there was a significant trend toward association with mortality ($P < .10$) by univariate analysis.

RESULTS

There were 123,581 patients identified undergoing vascular surgery procedures in NSQIP from 2007 to 2010. The average age of all patients was 67 ± 14 years; 59% were male. Comprehensive demographic data and comorbidities are shown in Table I. The most common comorbidities included hypertension (76%), current smoking (32%), obesity (30%), diabetes (28%), functional dependence (14%), and chronic obstructive pulmonary disease (12%). Procedures were grouped into broader categories, with the most common being cerebrovascular (25%), open lower extremity (23%), venous (11%) and endovascular abdominal procedures (10%), and endovascular thoracic procedures (10%). The full list of surgical procedures is shown in Table II. Postoperative cardiac arrest requiring CPR was seen in 1234 of 123,581 patients (1.0%) after vascular surgery. This occurred at an average of 7 ± 2 days. There were 158 cardiac arrests (12.8% of the total postoperative cardiac arrests) on postoperative day 0. There were 365 deaths of 472 arrests (77%) on postoperative days 0 to 2, and 555 deaths of 762 arrests (73%) ($P = .08$) on postoperative day 3 and later.

Multivariate regression revealed both patient and procedure characteristics that were associated with postoperative cardiac arrest. These included total functional dependence (odds ratio [OR], 2.9; 95% confidence interval [CI], 2.3-3.6; $P < .001$), dialysis dependence (OR, 2.7; 95% CI, 2.3-3.2; $P < .001$), emergency operation (OR, 2.2; 95% CI, 1.9-2.5; $P < .001$), partial functional dependence (OR, 2.0; 95% CI, 1.7-2.4; $P < .001$), need for ventilator 48 hours before operation (OR, 2.0; 95% CI, 1.5-2.7; $P = .001$), recent myocardial infarction (OR, 1.8; 95% CI, 1.4-2.3; $P < .001$), dyspnea on exertion (OR, 1.5; 95% CI, 1.2-1.9; $P < .001$), and being underweight (OR, 1.5; 95% CI, 1.2-1.9; $P < .001$) (Table III). Patients who had a do not resuscitate (DNR) order in their chart at some point 30 days prior were less likely to have a postoperative cardiac arrest requiring CPR.

Procedures that were associated with the highest risk for cardiac arrest included open thoracic surgery (OR, 6.9; 95% CI, 4.8-9.9; $P < .001$), open abdominal aorta surgery (OR, 3.7; 95% CI, 3.1-4.4; $P < .001$), excision of an abdominal graft (OR, 3.7; 95% CI, 1.5-9.2; $P < .001$), axillary-femoral bypass (OR, 2.1; 95% CI, 1.3-3.2; $P = .001$), and peripheral embolectomy (OR, 1.5; 95% CI, 1.2-1.9; $P = .002$) (Table IV).