

Role of cardiac evaluation before thoracic endovascular aortic repair

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Background: Patients with thoracic aortic disease undergoing thoracic endovascular aortic repair (TEVAR) often have concomitant coronary artery disease and are at risk for perioperative adverse cardiac events. Despite this risk, the need for and extent of preoperative cardiac workup before TEVAR remain undefined. This study seeks to assess the adequacy of a limited cardiac evaluation before TEVAR, including assessment of cardiac symptoms, resting electrocardiography (ECG), and transthoracic echocardiography (TTE), as well as to estimate the incidence of perioperative cardiac events in patients undergoing TEVAR.

Methods: Retrospective analysis of a prospectively maintained Institutional Review Board-approved database was performed for all patients undergoing TEVAR at a single referral institution between May 2002 and June 2013. The analysis identified 463 TEVAR procedures. All procedures involving median sternotomy were excluded, and 380 procedures (343 patients) were included in the final analysis. Degree of cardiac workup was classified on the basis of the highest level of preoperative testing: no workup, resting ECG only, resting TTE, exercise/pharmacologic stress testing, or coronary angiography. Standard workup consisted of cardiac symptom assessment along with resting ECG or TTE, with further workup indicated for unstable symptoms, significantly abnormal findings on ECG or TTE, or multiple cardiac risk factors. Categorical and continuous variables were compared by Fisher's exact test and analysis of variance, respectively.

Results: No preoperative cardiac workup was performed for 28 patients (7.4%); 127 patients (33.4%) had resting ECG only, 208 patients (54.7%) had resting echocardiography, 12 patients (3.2%) underwent stress testing, and five patients (1.3%) had coronary angiography. Patients undergoing stress testing or coronary angiography were older and had a higher incidence of known coronary artery disease ($P < .01$) and prior myocardial infarction ($P = .01$). Complex hybrid aortic repairs and TEVAR for aneurysmal disease were more likely to have an extensive workup, whereas nonelective procedures more commonly had no workup. A total of nine patients (2.4%) experienced a perioperative cardiac event (myocardial infarction or cardiac arrest), with no significant difference noted among all groups ($P = .45$), suggesting that the extent of cardiac workup was appropriate. The incidence of 30-day/in-hospital mortality (5.5%) and cardiac-specific mortality (0.8%) was similar among all groups.

Conclusions: The risk of a postoperative cardiac event after TEVAR is low (2.4%), and initial screening with either resting TTE or ECG, in addition to assessment of cardiac symptom status, appears adequate for most TEVAR patients. As such, we recommend resting TTE or ECG as the initial cardiovascular screening mechanism in patients undergoing TEVAR, with subsequent more invasive studies if initial screening reveals cardiovascular abnormalities. (*J Vasc Surg* 2014;60:1196-203.)

The incidence of cardiac events such as arrhythmias, myocardial infarction (MI), and cardiac-related morbidity is increased in patients undergoing major vascular surgery with rates ranging from 5% to 15%.¹⁻⁴ This increased incidence of cardiac morbidity and mortality is believed to be secondary to a high prevalence of underlying cardiac risk

factors, such as coronary artery disease (CAD), congestive heart failure, hypertension, hyperlipidemia, and diabetes, among the vascular surgery population.^{2,5} Patients undergoing thoracic aortic surgery are no exception and represent one of the highest risk groups for perioperative cardiac events.⁶

Given this potential for cardiac morbidity and mortality after major vascular surgery, many studies have examined patient risk stratification and methods of prevention of adverse cardiac events.^{7,8} Previous literature focusing on risk stratification has used a variety of methods ranging from simple scoring systems, such as the Eagle or Lee criteria, to complex metrics, such as preoperative cardiopulmonary exercise testing.^{2,9,10} In addition, certain studies have focused on the need for assessment and treatment of coronary stenosis for prevention of perioperative cardiac events.^{11,12} However, the majority of these studies have included primarily abdominal vascular surgical procedures, only elective cases, or have grouped both open and endovascular repairs. Further, although patients undergoing thoracic aortic surgery are thought to be at particular risk for perioperative cardiac events,⁶ there are data

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suggesting that the incidence of such adverse events may be reduced with endovascular compared with open surgery (in abdominal aortic procedures),³ and to date a consensus algorithmic approach to cardiac workup before thoracic endovascular aortic repair (TEVAR) has not been defined. Further, the exact cardiac risk associated with TEVAR has not been well characterized.

From the inception of our institutional TEVAR program, we have used a limited cardiac evaluation before TEVAR including assessment of cardiac symptoms, resting electrocardiography (ECG), and transthoracic echocardiography (TTE), although this approach has not been systematically studied to date. Further, because unnecessary preoperative workup can lead to delays in surgery and increased health care costs, a better understanding of the optimal cardiac evaluation for TEVAR patients is essential. As such, the purpose of this study was to assess the efficacy of a limited preoperative cardiovascular workup before TEVAR as well as to assess the incidence of adverse cardiac events after TEVAR.

METHODS

Patients and data source. A retrospective review was performed of prospectively collected data from all patients undergoing TEVAR at a single referral institution. Preoperative, intraoperative, and postoperative variables were abstracted from the Duke Thoracic Aortic Surgery Database, a prospectively maintained clinical registry of all patients who have undergone thoracic aortic surgery at Duke University Medical Center (Durham, NC). The study was reviewed and approved by the Duke University Institutional Review Board, and the need for individual patient consent was waived.

Inclusion criteria included any patient undergoing TEVAR since program inception in May 2002 through June 2013. Any patient who underwent concomitant median sternotomy as part of the TEVAR procedure was excluded from analysis. After query of the database, 463 TEVAR procedures were identified, of which 380 (343 patients) met study criteria. Comorbidities and patient characteristics were defined by the Society of Thoracic Surgeons definitions.¹³ Patients were stratified on the basis of the degree of preoperative cardiac workup they received. Examination of patient medical records, including admission history and physical examination, clinic notes, radiology, cardiac catheterization, and transfer records, was used to determine the extent of preoperative workup performed. The groups identified, in order of invasiveness, were no workup, resting ECG, resting TTE, exercise/pharmacologic stress testing, and coronary angiography. In cases in which multiple procedures were performed, patients were assigned to the group according to the highest level of preoperative workup received. Only tests performed as part of the preoperative workup for the TEVAR procedure were included for analysis.

Preoperative cardiac evaluation. Our institutional algorithm for pre-TEVAR cardiac workup consisted of assessment of cardiac symptoms with clinical history and

physical examination in all patients. Patients undergoing elective cases were then subject to resting ECG or TTE. In cases of multiple cardiac risk factors, unstable patient symptoms such as low-level exertional or resting angina, or markedly abnormal findings on ECG or TTE, further evaluation of the patient's cardiac status was undertaken (Fig). For nonelective procedures, only workup that would not delay surgery was done.

Outcomes. The primary study end point was the incidence of a perioperative cardiac event, defined as MI or cardiac arrest in the overall population as well as stratified by degree of cardiac workup performed. MI was defined by the occurrence of ST changes on ECG with accompanying rise of cardiac biomarkers.¹⁴ Secondary outcomes included 30-day/in-hospital and cardiac-specific mortality for both the overall population and stratified by degree of cardiac workup.

Statistical methods. After stratification of patients by the level of cardiac workup received, the Fisher's exact test or analysis of variance, for categorical and continuous variables, respectively, was used for comparison of patient and procedural characteristics and the aforementioned postoperative outcomes. An affirmative decision was made a priori to set the significance level at $\alpha = .05$ for all analyses. Statistical analysis was done with JMP Pro 10.0.2 (SAS Institute, Cary, NC) and R version 3.0.1 (Vienna, Austria).

RESULTS

The analysis identified 380 patients who met the study criteria. After stratification into the five predetermined groups, there were 28 patients (7.4%) who received no cardiac workup, 127 patients (33.4%) who underwent ECG alone, 208 patients (54.7%) with TTE, 12 patients (3.2%) with a stress test, and five patients (1.3%) with coronary angiography (Table I). Of the 12 patients who underwent a preoperative stress test, only one test result was positive for inducible ischemia (right coronary distribution) and did not lead to revascularization. Of the five patients undergoing coronary angiography, three had a positive functional study result leading to catheterization, whereas in two the decision was made to proceed directly to catheterization on the basis of preoperative cardiology consultation. Only one of the five patients undergoing coronary angiography had subsequent revascularization; this patient was status post two prior coronary bypass grafting operations and underwent multivessel percutaneous coronary intervention for a diseased saphenous vein graft as well as two native vessel stenoses.

Comparison of patient characteristics revealed significant differences in age of the patients and incidence of hypertension, hyperlipidemia, and tobacco abuse among the groups (Table I). In all cases, as the age of the patient and number of cardiac risk factors increased, the degree of workup increased accordingly. Analysis of cardiac comorbid disease burden (Table II) demonstrated that patients with known CAD or history of prior MI were significantly more likely to undergo more extensive preoperative cardiac

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