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EDITORIAL COMMENT

Ischemia, Revascularization, and Perioperative Troponin Elevation After Vascular Surgery*

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Perioperative cardiac risk may be related in several ways to the type of noncardiac surgery being performed. Some types of noncardiac surgery identify a group of patients at increased risk for concomitant cardiac disease based on shared risk factors that predispose patients to both noncardiac and cardiac disease. The most notable example of this relationship is seen with vascular surgery and coronary artery disease (CAD). The same factors that result in atherosclerosis of the peripheral arteries or the aorta may also predispose one to the development of CAD. Among such patients, CAD may be known or occult, with no symptoms because of the physical limitations associated with significant peripheral vascular disease. Risk stratification and optimal perioperative management are particularly important in these high-risk patients. As seen with patients undergoing coronary revascularization, several studies have demonstrated that even minor elevations in perioperative serum troponin concentrations are associated with significantly worse long-term survival after vascular surgery (1–3).

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The pathophysiology of perioperative myocardial infarction (MI) may differ from that of an MI occurring in the non-operative setting. Usually the rupture of a coronary plaque leads to platelet aggregation, which leads to thrombus formation and dynamic obstruction. In contrast, plaque rupture occurs in approximately half of perioperative MIs (4,5); the remaining 50% may be the result of a prolonged imbalance between myocardial oxygen supply and demand in the setting of fixed CAD (6). Oxygen demand may be increased by tachycardia and hypertension resulting from postoperative pain, withdrawal of anesthesia, or shifts in intravascular volume. An autopsy study by Dawood et al. (4) suggested that the underlying pathophysiology of most fatal perioperative MI is the disruption of an atherosclerotic plaque, leading to coronary thrombosis and dynamic obstruction of coronary vessels.

Several strategies, including coronary revascularization, have been used in patients with vascular surgery to reduce the incidence of perioperative MI and other complications. Although there are no prospective trials testing the impact of either preoperative coronary artery bypass grafting or percutaneous coronary intervention on perioperative cardiac morbidity and mortality rates, several retrospective studies have suggested that patients with successful previous coronary revascularization have a low risk of perioperative cardiac events during noncardiac surgery and that the risk of death may be comparable with that among patients with no clinical evidence of CAD (7–9). In this issue of the *Journal*, Landesberg et al. (10) prospectively collected data in 501 consecutive vascular procedures. Ischemia on thallium scan was associated with a 49% incidence of low-level and 22.4% incidence of conventional troponin elevation. On multivariate analysis, ischemia on thallium was the most important predictor of both low-level and conventional troponin elevations (adjusted odds ratio = 2.5 and 2.7, respectively; $p = 0.02$ and 0.04, respectively), whereas previous coronary revascularization predicted fewer troponin elevations (adjusted odds ratio = 0.35 and 0.16, respectively; $p = 0.045$ and 0.022, respectively). The authors concluded that troponin elevations occur frequently after vascular surgery. This phenomenon is strongly associated with postoperative ischemia, which is predicted by inducible ischemia on thallium scan and possibly reduced by preoperative revascularization.

This study is important in several respects. First, the analysis establishes an association between a high incidence of minor troponin elevation and preoperative CAD. Second, the study demonstrates the potential beneficial effect of coronary revascularization in reducing perioperative troponin elevation, which in turn has been shown to affect longer-term clinical outcome. Third, the data confirm recent reports of the underuse of evidence-based medical therapies such as beta-blockers, statins, and angiotensin-converting enzyme inhibitors in patients undergoing vascular procedures (11,12).

The study raises an important question as to whether patients undergoing vascular surgery should be routinely tested with preoperative imaging perfusion test and undergo revascularization if there is evidence of ischemia. Cardiac complications account for 50% to 60% of the morbidity and mortality observed after vascular surgical procedures, and appropriate preoperative measures may significantly reduce risk. In a selective review of several thousand vascular surgical procedures (carotid endarterectomy, aortic aneurysm resection, and lower-extremity revascularization), Hertzer (13) found that cardiac complications were responsible for approximately half of all perioperative deaths and that fatal events were nearly five times more likely to occur in the presence of standard preoperative indicators of CAD. Although the sensitivity of thallium imaging for detecting patients at increased risk is excellent, one

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of its limitations for preoperative screening is its low specificity and positive predictive value. To improve the value of risk stratification, many reports have suggested using a combination of clinical markers and noninvasive test results. Eagle et al. (14) first reported on using the assessment of clinical markers (history of angina, MI, congestive heart failure, diabetes, and Q-wave on electrocardiogram) and thallium redistribution to identify a low-risk subset of patients in patients undergoing vascular surgery. The authors demonstrated that patients without any of these clinical markers did not require dipyridamole thallium testing. However, thallium redistribution had a significant predictive value in patients with one or two clinical risk factors. Within this group, 2 of 62 (odds ratio 3.2%; 95% confidence interval 0% to 8%) patients without thallium redistribution had events, compared with 16 events in 54 patients (odds ratio 29.6%; 95% confidence interval, 16% to 44%) with thallium redistribution (14). L'Italien et al. (15) reported the results of a Bayesian model for perioperative risk assessment in vascular surgery candidates that combined clinical variables with dipyridamole thallium findings. This analysis examined the type of procedure, specific institutional complication rates, and other clinical factors in a sequential manner followed by the addition of the dipyridamole thallium findings. The addition of dipyridamole thallium data reclassified >80% of the moderate-risk patients into low- (3%) and high- (19%) risk categories ($p < 0.0001$) but provided no stratification for patients classified as low or high risk according to the clinical model. Despite these findings and the suggestion to use noninvasive testing only in patients of intermediate clinical risk, the identification of truly low-risk patients may be difficult based on clinical variables alone in patients with vascular disease. It also has been shown that even in patients who are at low risk clinically, a finding of ischemia with dipyridamole thallium testing is associated with an increase in the risk of MI by as much as 10-fold. In the study by Landesberg et al. (10) and Fleisher et al. (16), patients did not undergo thallium scanning if they had coronary angiography within the year prior to surgery with no subsequent change in symptoms, a negative exercise stress test with no history of CAD, and no clinical evidence of CAD. Patients who underwent bypass surgery in the previous five years or percutaneous coronary intervention from six months to five years previously and were free of clinical evidence of ischemia also may be included in this group and generally have surgery without further testing, particularly if they are functionally very active (16).

Finally, one needs to consider the suboptimal use of beta-blockers (<40%) and statins (30%) in this cohort, both of which have been demonstrated to reduce periprocedural events in patients undergoing vascular surgery (17,18). Whether coronary revascularization reduces periprocedural troponin elevation and clinical events in the presence of optimal medical therapy is not yet known. Until then, the indications for coronary revascularization should include patients with poorly controlled ischemic symptoms despite excellent medical therapy or patients with a large ischemic burden (>25% of the left ventricle) on stress perfusion imaging (19). In patients with such extensive ischemia, effective beta-blockade may not be sufficient to reduce the rate of perioperative cardiac complications (20). Whether coronary revascularization is offered or not, aggressive medical and preventive therapies are essential to improve long-term outcomes.

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