Introducing Cardiovascular Evaluation: Is There a Role for Coronary Computed Tomography Angiography?

James L. Furgerson, M.D.

Cardiology Service, Brooke Army Medical Center, Fort Sam Houston, TX

Introduction

Perioperative cardiovascular complications resulting from non-cardiac surgery are an important cause of morbidity and mortality. Using a step-wise approach and selective cardiac testing, those at highest risk of cardiovascular complications can be identified and offered medical therapy and revascularization – when indicated – in order to reduce the risk of perioperative myocardial infarction and other cardiovascular complications and improve their overall prognosis. Currently used non-invasive techniques have some limitations, especially in those who cannot exercise adequately prior to surgery. Coronary computed tomography angiography (CCTA) is now a well-established non-invasive technique which is very effective at identifying those with advanced multivessel and left main coronary artery disease and may have a future role in the cardiac evaluation of patients prior to non-cardiac surgery. In this review, current guidelines on perioperative cardiovascular evaluation are reviewed with a focus on non-invasive imaging techniques, including CCTA.

Noninvasive Preoperative Cardiovascular Assessment

Current guidelines for preoperative cardiovascular assessment call for careful clinical assessment to identify active cardiovascular conditions, such as unstable angina, decompensated congestive heart failure, and severe valvular heart disease. In patients without active conditions, the use of additional testing to further define cardiovascular risk is controversial and is generally reserved only for cases when the outcome of such investigation will affect subsequent management.

Consideration of noninvasive testing for coronary artery disease is appropriate when the patient will be undergoing intermediate or high risk surgery, has poor functional capacity, and carries three or more clinical risk factors. While exercise testing is preferred, preoperative patients are frequently not capable of exercising adequately, and a history of poor functional capacity exacerbates the problem of effectively exercising patients as a form of risk stratification prior to the planned procedure. For those patients who cannot exercise adequately, the following noninvasive options are available: vasodilator nuclear perfusion imaging, dobutamine stress echocardiography, dobutamine magnetic resonance imaging, vasodilator magnetic resonance perfusion imaging, and coronary CT angiography (CCTA). The diagnostic accuracy of these techniques is given in Table 1.

Vasodilator nuclear perfusion imaging, using adenosine, dipyridamole, or a newer adenosine agonist is supported by robust clinical investigation data showing its value in predicting perioperative events and outcomes. However, nuclear perfusion imaging in general is hampered by the occurrence of soft tissue attenuation and other imaging artifacts which can adversely affect the specificity of the test and its corresponding positive predictive value. Additionally, in patients with advanced multivessel disease, the presence of "balanced ischemia" may give...
a falsely negative test result, particularly when the added value of exercise ECG testing is not available. Dobutamine stress echocardiography also has extensive prior investigational data associated with its use in the periprocedural period, and is a useful test in patients who can tolerate dobutamine infusion and have adequate acoustic windows for detailed myocardial imaging, which is required for this test. While the risk of dobutamine infusion is relatively low and acceptable in most situations, care must be used to avoid precipitating ischemia and or complex ventricular arrhythmia with the administration of this agent. Additionally, considerable expertise is required on the part of the echocardiographic technician in obtaining adequate images and similar expertise is required by the interpreting physician, which may not be available in many centers.

Magnetic resonance imaging to detect inducible wall motion abnormalities with the infusion of dobutamine or by detection of perfusion defects with first pass imaging to vasodilator is well-developed in a few centers where operating characteristics are favorable compared with other noninvasive tests. However, this is not well proven in the perioperative setting.

CCTA is known to be a highly sensitive modality for detecting coronary atherosclerosis and has received increasing acceptance after multiple clinical trials have shown very good accuracy when compared with invasive coronary angiography. Radiation exposure, use of radiocontrast media, and limited specificity when imaging patients with extensive coronary calcium, large body habitus, and irregular rhythm, have traditionally been detractors of this technology. However, with the latest technology, radiation exposure has become acceptable in most clinical scenarios, and arrhythmia and body habitus are less problematic than in the past.

### Invasive Preoperative coronary Angiography

For preoperative patients who have undergone noninvasive testing, indications for preoperative invasive coronary angiography are similar to those identified in the nonoperative setting. Specifically, in the asymptomatic patient, the occurrence of high risk findings should lead to consideration for referral for invasive coronary angiography. Such high risk findings include greater than 10% ischemic myocardium or transient ischemic dilation by nuclear perfusion imaging, stress-induced wall motion abnormality in greater than or equal to two myocardial segments, or stress induced left ventricular dysfunction by stress echocardiography. In the patient with symptoms of ischemic heart disease, abnormal findings on noninvasive testing, baseline resting left ventricular

<table>
<thead>
<tr>
<th>Modality</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise ECG (27)</td>
<td>0.68</td>
<td>0.77</td>
</tr>
<tr>
<td>Exercise Echo (28)</td>
<td>0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Dobutamine Echo (28)</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Exercise Nuclear Perfusion (29)</td>
<td>0.87</td>
<td>0.73</td>
</tr>
<tr>
<td>Pharmacologic Nuclear (29)</td>
<td>0.86</td>
<td>0.75</td>
</tr>
<tr>
<td>Dobutamine MRI (9)</td>
<td>0.86</td>
<td>0.86</td>
</tr>
<tr>
<td>MRI Perfusion (8)</td>
<td>0.86</td>
<td>0.76</td>
</tr>
<tr>
<td>CT Coronary Angiography (11)</td>
<td>0.95</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Table 1. Accuracy of Noninvasive Techniques for Detection of Coronary Artery Disease.
dysfunction with a positive viability study, and high clinical suspicion of disease without further noninvasive testing would be indications for invasive coronary angiography. In a patient with established atherosclerotic heart disease, uncontrolled ischemic symptoms, which are worsening or limiting on medical therapy, and high risk findings by noninvasive testing might prompt referral for invasive coronary angiography.

Prophylactic revascularization prior to noncardiac surgery is a highly controversial practice. The rationale behind such revascularization seems to be that bypassing or dilating areas of high-grade stenosis within the coronary tree will prevent the occurrence of ischemia and ultimately infarction related to periods of high myocardial oxygen demand in the perioperative setting. However, this rationale is not well supported, and greater than half of all PMI is associated with in situ coronary thrombosis, which frequently occurs in areas without high-grade fixed disease preoperatively. Thus, the increase in inflammatory activity, procoagulant activity, and shear stress within the coronary tree and the affect of these factors on nonobstructive atheroma with subsequent plaque rupture and thrombosis is an important mechanism of PMI; this cannot be predicted by invasive coronary angiography or attenuated by coronary revascularization in many cases. However, some PMI is likely related to high-grade fixed disease and periods of supply-demand mismatch. Within the last decade, at least two important randomized clinical trials have been conducted to examine the role of prophylactic revascularization prior to high risk surgery. Both studies showed no improvement in short-term or long-term prognosis with successful preoperative coronary revascularization. Conversely, while also somewhat controversial, medical therapy using heart rate control has in general been shown to favorably affect outcomes in patients with ischemic heart disease when carefully provided.

Current guidelines for prophylactic revascularization are based on traditional indications for coronary bypass surgery in improving survival in patients with advanced coronary artery disease. Such patients include those with greater than 50% left main stenosis, greater than 70% stenosis in 3 epicardial vessels, greater than 70% stenosis in the proximal LAD with one additional vessel stenosis, those with two-vessel disease with extensive ischemia, and those with proximal LAD or two-vessel disease with left ventricular dysfunction and demonstrable viability. These indications for prophylactic revascularization are largely based on the individual’s coronary anatomy as determined by invasive coronary angiography. Additionally, a recent prospective randomized study of a systematic strategy of prophylactic coronary angiography versus a "selective strategy" using coronary angiography on the basis of abnormal noninvasive testing showed improvement in long-term outcome in patients who underwent routine invasive coronary angiography prior to vascular surgery.

Cardiac CTA

CTA is a highly sensitive test for coronary atherosclerosis with excellent sensitivity and specificity for coronary artery disease when compared with invasive coronary angiography (Figure 1). The negative predictive value for left main and left anterior descending artery obstruction by coronary CT angiography is especially high, which is of particular importance when identifying patients thought to benefit from prophylactic coronary revascularization prior to non-cardiac surgery. However, there are no randomized controlled data from clinical trials to examine outcomes when CTA is used in the preoperative setting. It is currently considered an "uncertain" indication for preoperative assessment in patients waiting intermediate to high risk surgery with a low functional capacity and who carry three or more clinical risk factors.

An ongoing clinical trial at Brooke Army Medical Center will examine the role of CTA versus vasodilator nuclear perfusion imaging in the preoperative assessment of patients awaiting intermediate to high risk surgery with three or more clinical risk factors who cannot adequately exercise. Since many of the patients enrolling in the study will have peripheral vascular disease and by proxy underlying advanced coronary atherosclerosis, the presence of coronary calcium may become problematic in identifying patients with left main and proximal three-vessel disease by CT angiography. Conversely, with a relatively high pretest likelihood of advanced coronary atherosclerosis, the potential for a false negative vasodilator perfusion scan related to
balanced ischemia will be a potential risk of the vasodilator perfusion imaging in this setting. If adequate coronary imaging can reliably be performed in this group of patients which will likely have rather advanced atherosclerosis, it is felt that CT coronary angiography will be an ideal method to identify patients at risk of ischemic complications in the perioperative period, as well as identifying patients who will benefit from prophylactic coronary revascularization and additional medical therapy.

It is likely that continued advances in CCTA, which will lessen imaging artifacts associated with coronary calcium, will lead to additional acceptance of the use of this modality in preoperative cardiovascular risk assessment. A similar anatomy-based approach has been suggested and is being tested in patients with non-acute symptoms of ischemic heart disease; it has been well established as a safe, effective, and cost-conscious means of evaluating those with acute symptoms of possible acute coronary syndrome and low or intermediate pretest probability of coronary artery disease.26

**Summary**

Perioperative cardiovascular complications resulting from non-cardiac surgery are an important cause of morbidity and mortality. Using a step-wise approach and selective cardiac testing, those at highest risk of cardiovascular complications can be identified and offered medical therapy and revascularization when indicated in order to reduce the risk of perioperative myocardial infarction and other cardiovascular complications and improve their overall prognosis. Currently used non-invasive techniques have some limitations, especially in those who cannot exercise adequately prior to surgery. Coronary computed tomography angiography (CCTA) is now a well-established non-invasive technique which is very effective at identifying those with advanced multi-vessel and left main coronary artery disease. Since much of the data supporting current guidelines on medical management and coronary revascularization of those at risk for perioperative adverse cardiovascular events are based on the presence and
severity of anatomic coronary stenoses, there is a strong rationale for use of CTTA in the preoperative assessment of these patients. Additional research data are needed to establish CTTA as an effective means of cardiovascular risk assessment prior to intermediate or high risk surgery. With further improvements in CTTA imaging technology, which will lessen the impact of coronary calcium on image quality, and additional research efforts, it is likely that CTTA will be accepted as an effective means of preoperative risk assessment strategies.

The views expressed in this material are those of the author, and do not reflect the official policy or position of the U.S. Government, the Department of Defense, or the Department of the Army or Air Force.

References


