Potential role of coronary computed tomography-angiography for guiding perioperative cardiac management for non-cardiac surgery

Amit K. Pahwa,[1] Armin Arbab-Zadeh,[2] Daniel J. Brotman,[1] Leonard S. Feldman[1]

[1]Hospitalist Program, Department of Medicine; [2]Division of Cardiology, Department of Medicine, The Johns Hopkins University, Baltimore, USA

Abstract

Perioperative cardiac events can be a major consequence of surgery. The American College of Cardiology Foundation/American Heart Association has set out guidelines to aid physicians in identifying patients at the highest risk for these events. The guidelines do recommend for some patients to undergo non-invasive cardiac stress testing for further risk stratification, but their sensitivity and specificity for predicting cardiac events is not optimal. With more data emerging of the superior performance of computed coronary tomography angiography (CCTA) compared to non-invasive stress testing, CCTA could be more useful in risk stratification for these patients.

Introduction

Major perioperative cardiac events occur in approximately 1% of non-cardiac surgeries, increasing patient morbidity, mortality, and length of stay.[1] According to the American College of Cardiology Foundation/American Heart Association (ACCF/AHA) 2007 Guidelines on Perioperative Cardiovascular Evaluation, non-invasive cardiac stress testing should be considered for patients undergoing moderate or high-risk surgery with poor functional capacity and at least one clinical risk factor. The intent of the testing is to further refine risk assessment for perioperative cardiac events and to determine the need for interventions prior to surgery aimed at reducing such a risk. The presence of obstructive coronary artery disease increases the risk of perioperative cardiac events. Although the obstructive lesion itself is often not the cause of the cardiac event, the lesion is a marker for advanced coronary atherosclerotic plaque burden and, among them, unstable plaques that are thought to lead to many of these events.[2] In addition to plaque type, other factors including alterations in coronary blood flow, changes in hemostasis, neurohormonal dysregulation, or other environmental stressors are typically required to incite an acute coronary event.[3] Surgery produces inflammation, catecholamine release, and a hypercoagulable state which can precipitate plaque rupture, thrombosis, and myocardial infarction (MI).[1] Dawood *et al.* showed, through autopsy review, that the pathophysiology of a fatal perioperative myocardial infarction is very similar to non-operative events. They compared the histopathology of myocardial infarction in patients who underwent surgery as well as those who did not. Plaque hemorrhage/rupture occurred in 55% of the perioperative group *versus* 40% of the non-operative patients (P=0.32), while thrombus without plaque disruption was noted in 29% *versus* 36% (P=0.59) of the perioperative *versus* non-operative patients, respectively.[4]

A review of the literature reveals only fair sensitivity and specificity of current non-invasive cardiac stress modalities *to predict cardiac events* in perioperative patients. Kertai *et al.* performed a meta-analysis of 58 studies with 8119 patients to determine the operating characteristics (sensitivity and specificity) of a variety of non-invasive stress tests performed before surgery. When evaluating for the likelihood of perioperative cardiac death and non-fatal myocardial infarction in vascular surgery patients, dobutamine stress echocardiography had the lowest (most favorable) negative likelihood ratio (LR), 0.21, while radionuclide ventriculography had the highest positive LR, 5.56.[5] Beattie *et al.* in their meta-analysis of 68 studies of 10,049 patients compared thallium imaging to stress echocardiography and determined that stress echocardiography had a better positive LR (4.09 *vs.* 1.83) and negative LR (0.23 *vs.* 0.44) for predicting a postoperative cardiac event.[6] Based on these numbers, a patient with a moderate perioperative cardiac event risk of 6% would have a post-test probability of 21% with a positive preoperative stress echocardiography study and a risk of 1% with a negative study.

More recently, computed coronary tomography angiography (CCTA) has emerged as a more sensitive test to non-invasively evaluate cardiac risk through imaging of the coronary arteries. Although there has only been limited experience with this modality in the perioperative setting, CCTA is able to accurately detect and exclude significant coronary artery disease (CAD) in many other clinical settings. A systematic review of 41 studies and 2500 patients with stable chest pain comparing CCTA to the gold standard diagnostic test, coronary angiography, found CCTA to have a sensitivity of 99% and specificity of 89% for detecting *flow-limiting CAD* defined as greater than 50% stenosis by quantitative analysis. This translates to a positive likelihood ratio of 9 and negative likelihood ratio of 0.01.[7]

Outcome: obstructive disease

In a recent review, pooled results from 7 studies and 483 patients showed a discrepancy

Correspondence: Amit K. Pahwa, Nelson 219, 600 North Wolfe Street, Baltimore, MD 21287, USA.
E-mail: pahwa@jhmi.edu

Key words: computed coronary tomography angiography, myocardial perfusion imaging, cardiac event.

Conflict of interests: the authors declare no potential conflicts of interests.

Received for publication: 1 September 2012.
Accepted for publication: 28 November 2012.

Heart International 2013; 8:e1
doi:10.4081/hi.2013.e1

between SPECT and CCTA for detecting more than 50% coronary artery stenosis. Using invasive coronary angiography as the reference standard, SPECT was 66% sensitive and 69% specific compared to the 96% sensitivity and 88% specificity of CCTA.[8]

A few studies have explored the use of CCTA in patients undergoing non-coronary cardiac surgery.[9-13] In the largest cohort of 70 patients preparing for valvular surgery, CCTA was 100% sensitive and 92% specific for detecting more than 50% stenosis in the coronary arteries when compared to invasive coronary angiography.[9]

Outcome: cardiac events

The prognostic value of CCTA has been well studied in emergency department (ED) literature. Gallagher *et al.* enrolled 85 low-risk patients who presented to the ED with chest pain. All had negative electrocardiogram (EKG) and serum markers for myocardial ischemia. All patients underwent myocardial perfusion imaging (MPI) and CCTA. MPI was considered abnormal if it showed reversible perfusion defects, and CCTA was deemed abnormal if there was greater than 50% stenosis. Patients were followed for 30 days to determine whether the patient had an acute coronary event such as unstable angina, non-ST elevation myocardial infarction (NSTEMI) or ST elevation myocardial infarction STEMI (by record review/questionnaire or invasive angiography). No events occurred in 78 patients while a major cardiac event occurred in 7 patients. In those who did not have an event, 70 of 78 had a negative MPI and 72 of 78 had a negative CCTA. Of the 7 who had an event, MPI and CCTA predicted 5 and 6 of them, respectively. These data suggest that CCTA is just as good, if not better than MPI in identifying those who will not have a major cardiac event.[14]

A 2011 systematic review and meta-analysis included 18 studies evaluating major cardiac events in 9592 symptomatic patients after evaluation with CCTA. Each patient had known or suspected coronary artery disease. Median follow-up time was 20 months. Major cardiac events were defined as death, myocardial infarction, or need for coronary revascularization. A CCTA was considered positive if a greater than 50% stenosis was identified. CCTA demonstrated high sensitivity (99%) and low negative LR (0.08) for a major cardiac event. Patients with a negative test had a much lower post-test probability of having an event.[15] Importantly, most of these studies included total mortality, but not cardiac mortality, as end points. If only cardiac mortality or myocardial infarction are considered, the event rate after a normal CCTA was zero even up to five years after testing.[16] Such negative predictive value is unmatched by other non-invasive tests. On the other hand, the specificity of only 41% produces a low positive LR (1.70) which means that a positive CCTA, using simply the presence of obstructive coronary artery disease, is a poor predictor of an impending major cardiac event.[15] To further investigate the negative predictive value of CCTA in low- to intermediate-risk patients (thrombolysis in myocardial infarction, TIMI 0-2) presenting to the ED with chest pain, Litt *et al.* randomized patients to a CCTA or *usual care* pathway. Of those studied in the CCTA pathway, 640 had a negative CCTA (less than 50% stenosis), and none of them died or had an MI within 30 days after presentation.[17] In addition, Hoffman *et al.* performed a multicenter study randomizing 1000 patients presenting to the ED with chest pain with any TIMI score to either standard ED evaluation or CCTA as first evaluation. Patients were followed for 28 days after discharge from the hospital. In the *usual care* pathway, there were 6 cases of acute coronary syndrome and only 2 in the CCTA group. Of note, the CCTA was positive for clinically significant disease in both of these patients, but they both had negative stress tests and were managed medically. In addition, there was no significant difference in number of catherizations, percutaneous intervention (PCI) or coronary artery bypass surgery (CABG) between each group.[18]

Can we use computed coronary tomography angiography in the perioperative setting?

The ACCF released *appropriate use* criteria for CCTA most recently in 2010. The foundation rates CCTA as appropriate to detect CAD in intermediate risk (10-90% CAD risk) patients. This refers to patients presenting with non-acute ischemic symptoms despite having an interpretable EKG or ability to exercise.[19] In addition, the ACCF recommends (while acknowledging uncertainty given the current body of evidence) using CCTA for preoperative evaluation on patients with less than 4 METS of functional capacity and at least one clinical risk factor undergoing intermediate risk or vascular surgery. Given the CCTA data discussed above, it may be reasonable to substitute CCTA for the other stress testing modalities, such as MPI. A recent study by Goldstein *et al.* looked at efficiency, cost, and safety of CCTA *versus* MPI in patients with no coronary artery disease presenting to the emergency department with acute chest pain and TIMI risk score below 4. There was no significant difference in number of major adverse cardiac events between the two groups. The costs of both tests are very similar, while the exposure to radiation is significantly lower with CCTA.[20]

Conclusions

Based on available data, CCTA is effective at excluding the presence of flow-limiting CAD and in identifying those patients with chest pain who are unlikely to have near-term coronary events. Absence of flow-limiting lesions appears to be a surrogate marker for low coronary atherosclerotic plaque burden and unstable coronary plaques. Given that stress echocardiography and MPI performance is, at best, only fair in risk-stratifying preoperative patients, and in other settings is inferior to CCTA, we suggest considering CCTA as an appropriate, and perhaps better way to stratify perioperative patients at risk for CAD if testing is indeed indicated (Table 1). CCTA is both sensitive and specific for detecting angiographically apparent obstructive CAD. Although there are no studies on the perioperative patient, the data on CCTA in other settings suggest it should be considered as a reasonable and possibly superior substitute for other non-invasive modalities. A randomized control trial comparing CCTA to other modalities in the preoperative setting is warranted.

Table 1. Likelihood ratios for various risk-stratification modalities.

Preoperative cardiac event	+LR	-LR
Dobutamine stress echocardiogram	2.83	0.21
Radionuclide ventriculography	5.56	0.55
Total mortality	+LR	-LR
CCTA	1.7	0.08

LR, likelihood ratio; CCTA, computed coronary tomography angiography.

References

1. Devereaux PJ, Goldman L, Cook DJ, et al. Perioperative cardiac events in patients undergoing noncardiac surgery: A review of the magnitude of the problem, the pathophysiology of the events and methods to estimate and communicate risk. CMAJ 2005;173:627-34.
2. Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol 1007;50:e159-241.
3. Arbab-Zadeh A, Nakano M, Virmani R, Fuster V. Acute coronary events. Circulation 2012;125:1147-56.
4. Dawood MM, Gutpa DK, Southern J, et al. Pathology of fatal perioperative myocardial infarction: implications regarding pathophysiology and prevention. Int J Cardiol 1996;57:37-44.
5. Kertai MD, Boersma E, Bax JJ, et al. A meta-analysis comparing the prognostic accuracy of six diagnostic tests for predicting perioperative cardiac risk in patients undergoing major vascular surgery. Heart 2003;89:1327-34.
6. Beattie WS, Abdelnaem E, Wijeysundera DN, Buckley DN. A meta-analytic comparison of preoperative stress echocardiography and nuclear scintigraphy imaging. Anesth Analg 2006;102:8-16.
7. Mowatt G, Cummins E, Waugh N, et al. Systematic review of the clinical effectiveness and cost-effectiveness of 64-slice or higher computed tomography angiography as an alternative to invasive coronary angiography in the investigation of coronary artery disease. Health Technol Assess 2008;12:iii-iv,ix-143.
8. Arbab-Zadeh A. Stress testing and noninvasive coronary angiography in patients with suspected coronary artery disease: time for a new paradigm. Heart International 2012;7:e2.
9. Meijboom WB, Mollet NR, Van Mieghem CA, et al. Pre-operative computed tomography coronary angiography to detect significant coronary artery disease in patients referred for cardiac valve surgery. J Am Coll Cardiol 2006;48:1658.
10. Gilard M, Cornily JC, Pennec PY, et al. Accuracy of multislice computed tomography in the preoperative assessment of coronary disease in patients with aortic valve stenosis J Am Coll Cardiol 2006;47:2020-4.
11. Manghat NE, Morgan-Hughes GJ, Broadley AJ, et al. 16-detector row computed tomographic coronary angiography in patients undergoing evaluation for aortic valve replacement: comparison with catheter angiography Clin Radiol 2006;61:749-57.
12. Reant P, Brunot S, Lafitte S, et al. Predictive value of noninvasive coronary angiography with multidetector computed tomography to detect significant coronary stenosis before valve surgery. Am J Cardiol 2006;97:1506-10.
13. Scheffel H, Leschka S, Plass A, et al. Accuracy of 64-slice computed tomography for the preoperative detection of coronary artery disease in patients with chronic aortic regurgitation Am J Cardiol 2007;100:701-6.
14. Gallagher MJ, Ross MA, Raff GL, et al. The diagnostic accuracy of 64-slice computed tomography coronary angiography compared with stress nuclear imaging in emergency department low-risk chest pain patients. Ann Emerg Med 2007;49:125-36.
15. Hulten EA, Carbonaro S, Petrillo SP, et al. Prognostic value of cardiac computed tomography angiography a systematic review and meta-analysis. J Am Coll Cardiol 2011;57:1237-47.
16. Andreini D, Pontone G, Mushtaq S, et al. A Long-Term Prognostic Value of Coronary CT Angiography in Suspected Coronary Artery Disease. JACC Cardiovascular Imaging 2012;5:690-701.
17. Litt HI, Gatsonis C, Snyder B, et al. CT angiography for safe discharge of patients with possible acute coronary syndromes. N Engl J Med 2012;366:1393-403.
18. Hoffmann U, Truong QA, Schoenfeld DA, et al; ROMICAT-II Investigators. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med 2012;367:299-308.
19. Taylor AJ, Cequeira M, Hodgson JM, et al. ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 appropriate use criteria for cardiac computed tomography: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. J Am Coll Cardiol 2010;56:1864-94.
20. Goldstein JA, Chinnaiyan KM, Abidov A, et al. The CT-STAT (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment) Trial. J Am Coll Cardiol 2011;58:1414-22.