Commentary

Use of CT angiography among patients with prior coronary artery bypass grafting surgery

Charles Eisenberg[1], Edward Hulten[1,2], Marcio Sommer Bittencourt[2,3], Ron Blankstein[2]

[1]Cardiology Service, Department of Medicine, Walter Reed National Military Medical Center and Uniformed Services University of Health Sciences, Bethesda, USA; [2]Cardiovascular Division and Department of Radiology, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA; [3]Center for Clinical and Epidemiological Research, University Hospital and State of São Paulo Cancer Institute (ICESP), University of São Paulo, São Paulo, Brazil

Correspondence to: Ron Blankstein. Cardiovascular Imaging Program, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115, USA. Email: rblankstein@bwh.harvard.edu.

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Given the inherent challenges in performing invasive coronary angiography (ICA) in patients who have coronary artery bypass grafts, there has been great interest in developing safe and accurate non-invasive techniques to assess graft patency. Clinically, such an evaluation is often required when patients present with symptoms suggestive of ischemia. However, while coronary computed tomography angiography (CTA) has been extensively studied in patients without known prior coronary artery disease (CAD), the role of CTA remains less clear for patients with prior coronary artery bypass grafting (CABG) surgery. Addressing the need for more data in this area, Drs. Barbero and colleagues published in the *International Journal of Cardiology* a comprehensive review on this topic: "64 slice-coronary computed tomography sensitivity and specificity in the evaluation of coronary artery bypass graft stenosis".

Accuracy of CT angiography in evaluating bypass grafts

Dr. Barbero and colleagues conducted a systematic review and meta-analysis of ten studies representing 959 patients with prior CABG surgery, who had a total of 1,586 bypass grafts. This analysis was restricted to studies utilizing at least 64-multidetector CT (MDCT). The pooled sensitivity and specificity of detecting complete graft occlusions was 99% and 99% respectively as compared to the standard of ICA (1). Further meta-analysis of 12 studies covering 2,482 grafts generated a pooled sensitivity of 98% and specificity of 98% using CTA to localize significant graft stenosis (defined as greater than 50 percent). These impressive estimates of accuracy persisted across all studies regardless of the age of patients or grafts (1). Furthermore, complete evaluation of all bypass grafts was successful in 93–100% of patients.

The results provided by Barbero *et al*. reflect the fact that CTA is particularly effective in studying bypass grafts due to their large size, lower degree of calcifications, and decreased motion when compared to native vessels. Unfortunately, this meta-analysis did not evaluate pooled sensitivity and specificity of CTA for detecting native vessel disease, as clinically ischemia may be caused by disease in native vessels which were not grafted, or in native vessels distal to the site of anastomosis. The challenge with evaluating the native vessels is that a substantial proportion of patients may have large amount of calcified plaque which can render such vessels to be non-evaluable. There are few studies reporting accuracy of CTA to diagnose stenosis in native ungrafted coronary arteries, but in three prior studies, sensitivities ranged from 86% to 97% and specificities from 76% to 92% (2-4). Despite these fairly reassuring accuracy studies, in clinical practice functional imaging often proves more practical than CTA when evaluating patients with prior CABG, especially when concern exists regarding progression of disease in ungrafted native vessels.

Using CTA to limit or guide ICA

Evaluation by ICA in patients with prior CABG can be challenging and expose patients to large contrast volumes in addition to rare complications such as injury to the graft vessel during catheter engagement. Although both ICA and CTA have a low risk of contrast-induced nephropathy, advances in CTA technology have reduced the amount of contrast needed for such cases to ~50–80 cc. The authors of the present meta-analysis cite previously published data showing similar radiation dose of CTA compared to ICA (5). The meta-analysis by Barbero *et al*. highlighted the potential "gatekeeper" role of CTA to avoid ICA, which is associated with higher procedural cost, patient inconvenience due to need for sedation with resultant driving restrictions, as well as a low but non-zero risk of stroke, infarction, dissection, arrhythmia, or death (1). However, it is important to emphasize that most of the advantages of CTA will only be realized if this test can avoid the need for ICA. Another use of CTA is to evaluate patients with unknown number and position of grafts when an ICA is planned. Upstream CTA has the potential to make ICA faster and more efficient due to an improved understanding of CABG anatomy prior to attempting to engage graft ostia and evaluate graft body, touch-down, and distal coronary perfusion in the catheterization lab. While performing both CTA and ICA results in a higher radiation and contrast dose, there is no data on how much a pre-ICA CTA may lower fluoroscopy time or cumulative contrast load.

Prognostic value of CTA

The high sensitivity and specificity reported by Barbero *et al*. support improved diagnostic accuracy of contemporary CTA techniques when compared to prior studies which included 4- or 16-detector CT systems. As more bypasses are performed and grafting techniques continue to improve, earlier identification of diseased grafts and better knowledge of graft anatomy could further improve outcomes. Further supporting the need to improve outcomes is the fact that patients with prior CABG who have "unprotected coronary territories" (disease in a bypass graft, an ungrafted native vessel, or a native vessel distal to the anastomosis) appear to have adverse long-term outcomes (6). Further, identifying the number of unprotected territories by CTA yields incremental prognostic information on the risk for myocardial infarction and death (6). Yet, any potential benefit of CTA in this setting only occurs if the information provided by CTA would favorably impact clinical decision making. Ultimately, CTA—together with clinical data, and in many cases data from other tests that can assess for the presence, location, and severity of myocardial ischemia—may be used to more selectively choose which sub-group of symptomatic patients are most likely to benefit from invasive angiography and potential intervention. CTA is not going to be appropriate for all patients, and patient selection along with consideration of other available techniques will remain essential.

Patient selection for CTA

Certain clinical scenarios may have a compelling role for CTA over ICA. These include cases when prior ischemic testing suggest possible disease in the distribution of a known bypass graft (i.e., mid to distal LAD) when disease distal to the anastomosis seems less likely. Other roles for CTA include cases when an anatomic correlation may be helpful following an equivocal functional test. Repeat evaluation of patients with previously demonstrated borderline graft stenosis and change in symptoms would be another scenario. Finally, other unique indications when CTA may be helpful include evaluation of proximal grafts (which may be affected in cases such as vasculitis) or evaluation of bypass graft aneurysms (7).

However, patients with significant obesity (e.g., body mass index >40 kg/m^2) or who have irregular heart rhythms may not be ideal candidates for CTA. In addition, individuals with a large number of metallic surgical clips, and those with stage 4 chronic kidney disease (CKD) with glomerular filtration rate below 30 mL/min are also not good candidates for CTA.

Given the need for invasive angiography to define some distal and calcified native vessels, clinical suspicion for coronary stenosis in heavily calcified native coronaries should prompt consideration of testing other than CTA such as functional ischemic testing or ICA. Functional studies, rather than CTA, would also be appropriate in patients with a history of known stenosis and worsening symptoms to better correlate symptoms with physiology.

Future studies

Although CTA is highly accurate for the diagnosis of CABG graft stenosis or occlusion, the functional significance of these lesions often cannot be determined without incurring downstream costs for further testing. Further research should better define which bypass patients may be suitable candidates for CTA as well as how to better integrate data from functional and anatomic testing to identify which patients are most likely to benefit from coronary revascularization. Potentially, such data could be derived in the future from CT using mathematically modeled Fractional Flow Reserve (FFR_{CT}). However, this technology has not undergone rigorous validation among patients with prior CABG and current limitations of cost, as well as the logistics of sending CTA data to off site, may limit the adoption of this technology. If FFR_{CT} or similar mathematical modeling techniques of coronary physiology become easier to obtain, and have adequate reliability at an individual patient level among patients with prior CABG, the value of CTA as a stand-alone test to prevent unnecessary invasive evaluation could increase.

Identifying bypass graft stenosis or occlusion can generate downstream costs with an unclear net benefit for survival. As patients with a history of CABG should already be on aggressive medical therapy, future studies will need to address the cost-effectiveness of diagnostic testing and resulting coronary intervention to improve anginal symptoms and reduce future risk of myocardial infarction and death. It will take long-term follow-up studies with CTA to demonstrate net cost savings in terms of total healthcare expenditures and quality of life years saved as a result of making such interventions. Additional investigation can determine the cost effectiveness of CTA together with other non-invasive functional testing versus invasive angiography for the evaluation of recurrent symptoms in this high risk population.

Future studies may also explore the potential use of CTA to screen patients for early graft failure immediately following CABG, or at set intervals. Bassri *et al*. has demonstrated that arterial grafts were 95% patent and venous grafts were 90% patent in the early postoperative period and that CTA can correctly identify the graft failures (8). As graft failure rates are still relatively high despite improvements in operative and post-operative care, identifying candidates for intervention earlier may improve longer-term outcomes. This would require further investigation via a prospective trial that would need to assess patient outcomes in addition to downstream costs and resource utilization.

Conclusions

While CTA offers excellent accuracy for the detection of bypass graft stenosis or graft occlusion, this test is more limited for evaluating native vessels. Thus, more data is needed on how to most optimally select which individuals are most likely to benefit from a primary CTA strategy, and when and how such testing may be integrated with other non-invasive functional approaches. Future studies will need to delineate how to apply the strengths of CTA to carefully selected sub-groups, in order to improve patient outcomes while reducing unnecessary invasive evaluations.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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