Approaches to Risk Stratification for TEVAR

Current evidence and future directions using ECG-gated computed tomography.

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The introduction of thoracic endografts for the treatment of thoracic aortic disease has altered pre- and postoperative evaluation. The decision to pursue endovascular treatment requires additional diagnostic imaging when compared to traditional open repair.[1] Currently, the vast majority of preoperative imaging used for patient selection, when contemplating thoracic endovascular aneurysm repair (TEVAR), is performed using static imaging.[2] The most commonly used modality is computed tomographic angiography (CTA).[3] These static imaging protocols do not consider aortic dynamics and may result in aortic sizing failures and graft-to-aorta mismatch. Aortic compliance and cardiac pulsatility result in subsequent aortic anatomic changes throughout the cardiac cycle.[4] Furthermore, thoracic aortic area diameter specifically has been reported to vary as much as 17% during the cardiac cycle.[5] The use of dynamic-gated CT scanning in the authors' practice provides a better understanding of the native aortic environment into which the thoracic endograft is placed and may aid in both patient and device selection. We have expanded our use of gated CT scanning in an effort to aid in cardiac risk stratification, as well as TEVAR sizing (Figures 1 and 2).

Coronary artery disease is a significant risk factor in patients with thoracic aortic aneurysms, with a prevalence as high as 30% to 70%.[6] The Swedish Heart Surgery registry revealed that 43% of perioperative deaths during surgery for aortic aneurysm or dissection resulted from a cardiac cause.[7] The greatest cause of TEVAR mortality is cardiac in origin. Knowledge of underlying and potentially significant cardiac pathologies preoperatively may improve patient selection, prediction of patient outcome, and, therefore, may lead to improved results for endovascular thoracic aortic surgery.

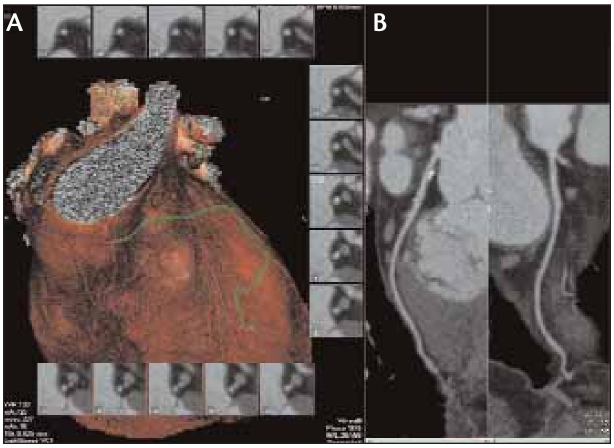

Figure 1. An ECG-gated CTA three-dimensional reconstruction of the coronary vasculature (A). The left anterior descending artery demonstrates a small area of calcification and relatively mild disease (B).

NEW INSIGHTS WITH DYNAMIC IMAGING

Almost all patients selected, for whom thoracic aortic surgery is planned, undergo CT scanning with contrast. CT angiography is the method of choice for patient

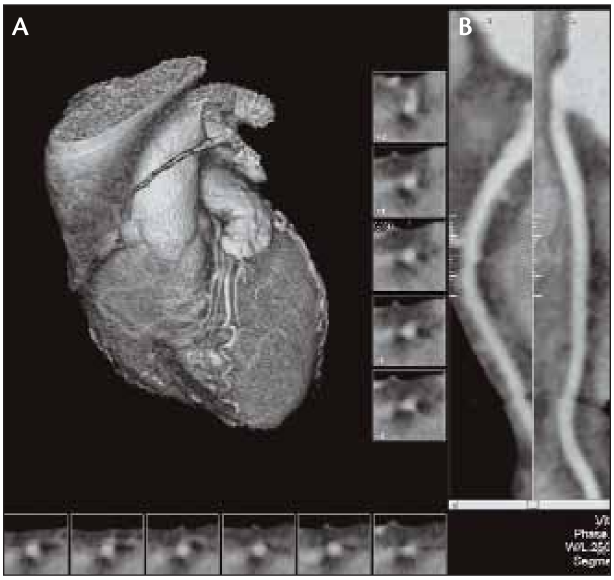

Figure 2. An ECG-gated CTA three-dimensional reconstruction of the right coronary artery (A). A reformatted view demonstrates mild-to-moderate disease (B).

Figure 3. Cross-sectional views of the coronary vasculature are calcified and easily visualized, which may be used for coronary calcium scoring.

selection and procedural planning in patients with thoracic aortic pathologies. Recently, a new imaging modality, electrocardiogram (ECG)-gated CTA, has undergone an enormous evolution, and its role as a diagnostic imaging modality in clinical care appears to be expanding. The three-dimensional volumetric datasets allow the clinician to rotate the aorta into a number of views to best visualize the aortic pathology while obtaining images at different phases of the cardiac cycle. This has been demonstrated to be of particular importance in sizing of the graft.[7] Gating by ECG has been proposed by some investigators to be a mandatory addition for ascending aorta CT angiograms.[8,9] Motion artifacts often cause false-positive detections of thoracic aorta dissection in nongated CT images. When ECG gating is used, the effect of motion artifact is minimal and diagnostic accuracy improved.[10]

SIMULTANEOUS CARDIAC RISK STRATIFICATION WITH ECG-GATED CTA

Several articles describe the high diagnostic accuracy of ECG-gated CT for the assessment of coronary anatomy and cardiac function.[11-16] Assessments of gated CTA for valve characteristics, valvular motion, correlation with end-systolic and diastolic volumes, and ejection fraction have also been documented.[17,18] A novel advantage of ECG-gated CTA, which most cardiac tests lack, is the opportunity to study both cardiac and extracardiac pathologies, including those of the lungs, mediastinum, and thoracic aorta. The relatively small risk of contrast administration and radiation exposure limits the use of gated ECG as a large screening tool for coronary artery disease in the general population.[19] However, for patients with thoracic pathology who are at increased risk from coronary disease, these risks may be balanced by the additional information gained from ECG-gated CT. ECG-gated CT may be a perfect replacement for regular CT in patients who need thoracic aortic surgery

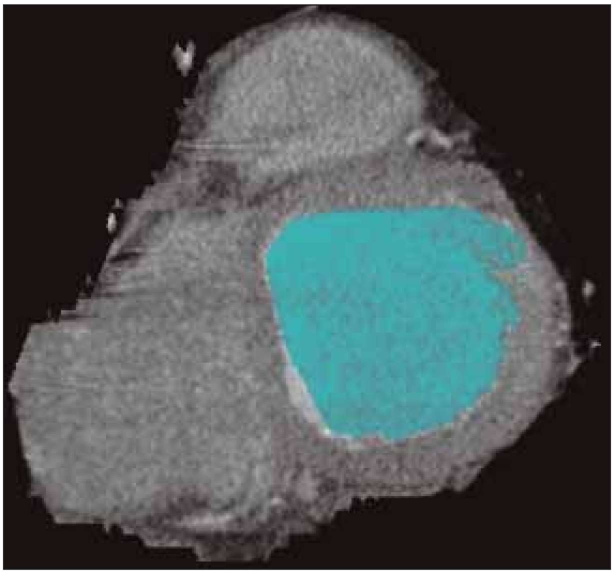

Figure 4. Multiple dynamic images throughout the cardiac cycle may be used to estimate end-systolic and diastolic volumes and ejection fraction.

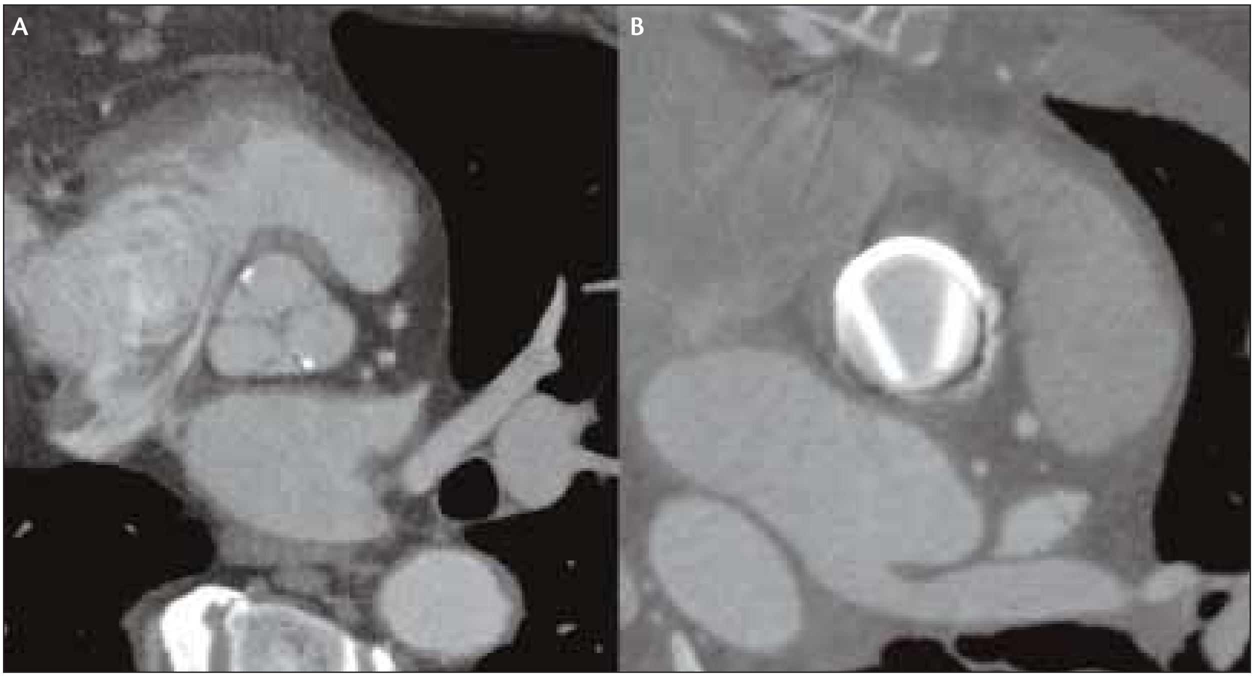

Figure 5. Cross-sectional views may also be used to visualize the heart valves. Using ECG-gated CTA, it is easy to reveal the three leaflets of the aortic valve (A). One can identify a prosthetic valve open during the systolic phase of the cardiac cycle (B).

because one scan may be sufficient for both thoracic aortic visualization and assessment of cardiac function. This information may then be used for subsequent risk stratification before thoracic intervention.

Recently, the feasibility of dynamic imaging of the thoracic aorta and cardiac risk stratification has been realized with a single ECG-gated CT. Schlösser et al retrospectively reviewed patients imaged with ECG-gated, 64-detector row CT for thoracic pathology, including thoracic aneurysms and dissections.[20] All patients were also successfully assessed for calcium scores (Figure 3), coronary artery stenosis, coronary artery anomalies, interventricular septal wall thickness, myocardial scar, left ventricular ejection fraction (Figure 4), muscle mass, and aortic and mitral valve anatomy (Figure 5). These factors can be used to risk-stratify patients prior to surgical intervention. For example, coronary calcium deposits are visualized on ECG-gated CT and can be used to generate coronary calcium scores. These have been demonstrated to correlate with atherosclerotic burden and may therefore predict future cardiovascular events.[21] This study demonstrated that the differences in images obtained from cardiac and thoracic pathology is feasible with a single CT scan.

Several differences exist between helical CT scanning and ECG-gated CT, and there are additional steps required for successful ECG-gated CTA. Initially, intravenous access for contrast administration and three

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ECG leads are required, while the highest gantry rotation speed and thinnest slice thickness are selected. It may be necessary to adjust the gantry rotation speed depending on the patient's heart rate. Highly concentrated and rapidly injected contrast media can also be utilized to increase vascular enhancement. A smaller field of view should be selected to cover the cardiac structures. Analysis of data acquired can be time consuming and, in our experience, may take up to 30 minutes per patient. Furthermore, the large number of images generated, which may range between 3,000 and 6,000 images per patient, may slow down in-hospital network computers significantly. Finally, ECG imaging of the aorta requires a longer patient breath hold than a coronary ECG-gated CTA (approximately 10 seconds vs 3 seconds in this recent study).

Whether physicians will choose to implement preoperative cardiac risk stratification using ECG-gated CTA remains to be seen. The excellent negative predictive value of ECG-gated CTA makes the presence of atherosclerotic plaque very unlikely.[18] Perhaps the significant risks and increased cost of invasive cardiac angiography can therefore be avoided in this selected subset of patients. If coronary arterial disease is demonstrated or if further cardiac lesions are apparent on ECG-gated CT, additional diagnostic imaging may be required. Moreover, this information could also be used for coronary artery bypass grafting or any other thoracic intervention that may be indicated.

> "Adequately designed prospective studies examining postoperative outcomes in patients screened with ECG-gated CT are required."

CONCLUSION

Cardiac structures are routinely acquired during ECG-gated CT of the thoracic aorta, and disregard of this significant amount of information may represent a missed opportunity for clinicians to detect underlying patient disease. Interventionists should thoroughly review ECG-gated images to obtain the appropriate information within the examination and to further scrutinize cardiac anatomy and function. Despite the wealth of information and advantages provided from ECG-gated CT, no prospective studies exist at this time to demonstrate improved outcomes when acquiring data with ECG-gated CT. Adequately designed prospective studies examining postoperative outcomes in patients screened with ECG-gated CT are required. Furthermore, with improved future developments in CT scanning technology, this modality may become a primary screening tool for risk stratification for those undergoing thoracic aortic intervention. ■

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