Non-coronary findings in cardiac CT

Dr Swamy Gedela
Consultant cardiothoracic radiologist
Essex Cardiothoracic Centre

Gated multi-detector CT (MDCT) is now recognised as an excellent and robust application for non-invasive assessment of coronary arteries, and in many centres is routinely used. Some studies have shown that MDCT scanners with 64-detector row have a 99% negative predictive value for the detection of coronary artery stenosis. MDCT images obtained with ECG gating are superior to the standard (non-ECG-gated) studies due to reduction in blurring secondary to cardiac and respiratory motion.

One issue with gated MDCT was the dose. Previously, gated MDCT was routinely acquired with retrospective ECG-gating, with data acquired throughout the entire cardiac cycle. This was at the expense of increased radiation dose, although not all data was used for post-processing or reconstructions. Now routinely prospective ECG-gating is used by turning off the x-ray beam during most of the cardiac cycle, with only a portion of the cardiac cycle that is radiated selected before the scan, resulting in significant reduction in radiation dose compared to retrospective ECG-gating.

Further technological advancements, combined with substantial improvements in image acquisition and analysis, have led to additional reduction in dose without compromising image quality. As a result, the utility of MDCT can now be extended beyond the assessment of the coronary arteries to answer a multitude of clinical questions within cardiovascular medicine, in conjunction with other modalities such as echocardiography and cardiac magnetic resonance (CMR). This review will discuss gated MDCT as an emerging tool for non-coronary cardiac applications.

Pericardium

Although echocardiography is the first-line modality for assessment of pericardial disease, MDCT provides excellent delineation of pericardial anatomy, and has the advantage of the ability to image the entire pericardium which may not be the case with echocardiography, due to restricted acoustic windows. It can be used to evaluate pericardial effusions, tamponade, constrictive pericarditis, pericardial masses and congenital anomalies – a thickness of 4mm or more is considered abnormal. This may result from a variety of conditions including pericarditis, connective tissue disease, uraemia, sarcoidosis and mediastinal irradiation. MDCT is especially useful for pericardial calcification, which in conjunction with constructive physiology suggests constructive pericarditis (figure 1).

Cardiac tumours

The aim of imaging in the assessment of a suspected cardiac tumour is to confirm its presence, anatomical location, its relation to adjacent structures, tissue characterisation, and to assess functional impact. CMR and echocardiography are the preferred modalities, however MDCT can provide excellent spatial and contrast resolution. In addition to assessing extra cardiac structures such as lung parenchyma, it can be useful for the evaluation of calcification and fat content within a mass. The use of attenuation measurements may further aid in tissue characterisation.

Atrial myxoma is the most common benign cardiac tumour, comprising 50% of tumours. Differentiating atrial myxoma from thrombus is important. Myxomas tend to be larger, attached to the inter-atrial septum, have a stalk, and can prolapse through the mitral valve (figure 2).

Valves

Echocardiography is the gold standard and first-line imaging modality for assessment of valvular heart disease. However, cardiac CT has a role, in particular depiction of calcification, thickening, and planimetric measurement of the valve orifice (figure 3). Other applications include aortic root abscess, pseudoaneurysms and secondary signs of valvular disease as a result of pressure or volume overloading (figure 4). CT can also identify congenital valvular anomalies.

Transcatheter aortic valve implantation

Aortic stenosis is a common disorder, and valve replacement is indicated in severe aortic stenosis. However, patients with significant co-morbidities may not be considered candidates for surgical aortic valve replacement because of high operative risk. Transcatheter aortic valve implantation (TAVI) is a novel method to treat selected high risk patients with aortic stenosis. An understanding of the complex anatomical relationships of the left ventricular outflow tract, aortic annulus, aortic root and coronary arteries are crucial for pre-procedural planning. MDCT is playing an increasingly important role and is considered gold standard for providing detailed anatomical assessment of the aortic root and valve annulus with precise accuracy, in unlimited three dimensional imaging planes.

Pulmonary veins

Pre-procedural planning is essential for patients requiring pulmonary vein ablation who have drug refractory atrial fibrillation. Cardiac CT has been shown to be an excellent tool to accurately depict pulmonary vein anatomy which can help guide the electrophysiologist, including selection of appropriately sized ablation catheters. Post procedural complications such as thrombus and pulmonary vein stenosis can also be shown on cardiac CT.

Cardiomyopathies

Echocardiography and CMR are the gold standard investigations and the imaging modalities of choice in the assessment cardiomyopathies, due to the information provided on regional and global LV function and tissue characterisation. However, MDCT offers several additional advantages, especially if echocardiographic images are not completely diagnostic. These include short acquisition time, no MRI-specific contraindications, and the ability to evaluate the coronary arteries simultaneously.

Dilated cardiomyopathy is characterised by LV enlargement with associated systolic dysfunction in absence of abnormal loading conditions and ischaemic heart disease (figure 5). Hypertrophic cardiomyopathy involves asymmetric hypertrophy of the interventricular septum. Other less common types of cardiomyopathy that may be appreciated on cardiac CT include arrhythmogenic right ventricular dysplasia and left ventricular non-compaction.
Myocardial infarction

Emerging application of cardiac CT involves rest and stress perfusion of the myocardium. However, with standard MDCT, areas of infarction can be seen as areas of reduced attenuation. In the acute setting this is due to a perfusion abnormality secondary to oedema (figure 6).

Congenital heart disease and shunts

Echocardiography and CMR are the main modalities for investigation of congenital heart disease. Cardiac CT is a useful adjunct in patients who are unable or unwilling to undergo cardiac MRI. In addition, the spatial and temporal resolution and unrestricted field of view enables this to be an excellent tool for the anatomical localisation of intra cardiac shunts, systematic evaluation of the aorta, pulmonary artery and veins, cardiac chambers, ventriculo-arterial connections and visceral situs (figures 7 and 8). Vascular lesions, such as aortic coartation and complex congenital heart disease can be well visualised.

Conclusion

For non-coronary cardiac assessment of morphological and functional information, echocardiography and cardiac MRI are the primary imaging modalities. However, applications of ECG-gated MDCT are ever increasing and it is a viable complementary imaging modality. Radiologists should be aware of the findings and applications of utilising gated CT beyond non-invasive coronary angiography.

References


Figure 1

Transaxial CT image in a patient with constrictive pericarditis. There is a calcified and thickened pericardium (arrow) and distortion of the left ventricle (LV).

Figure 2

Transaxial CT image in a patient with a calcified left atrial myxoma (*), features are atypical compared to classical appearances.

Figure 3

Short axis CT image in a patient with calcified functionally bicuspid aortic valve.

Figure 4

Coronal CT image showing a dilated aortic root with incomplete coaptation of the aortic valve leaflets and a dilated left ventricle secondary aortic regurgitation.
**Figure 5**
Transaxial CT image showing a dilated left ventricle in the presence of normal coronary arteries and valves.

**Figure 6**
Two-chamber CT image showing transmural reduced attenuation at the anterior wall (arrow), secondary to myocardial oedema in a patient with an acute left anterior descending artery infarct.

**Figure 7**
Transaxial CT image in a patient with a sinus venosus atrial septal defect (*). RA, right atrium; LA, left atrium.

**Figure 8**
Volume rendered image showing a patent ductus arteriosus.