CT coronary angiography in 2016
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CT imaging of the heart is a relatively new diagnostic tool, used primarily for imaging of the coronary arteries. In this edition of the NZMJ, Ellis et al describe their use of this technique in a private practice setting over a period of eight years.1

The first paper on cardiac CT was published by Sagel et al in 1977,2 only four years after the development of the first ‘EMI’ scanner.3 The authors of this work notably included Godfrey Hounsfield, the electrical engineer who conceived of and developed the CT scanner, with funding from the royalties of the Beatles’ music, thereby earning himself a Nobel prize, a knighthood and the enduring gratitude of radiologists everywhere (his name is given to the unit of radiographic density). They used the patient’s ECG to synchronise the x-ray beam being turned on and off with the cardiac cycle, and claimed to have achieved an improvement in image quality. However, image acquisition still took a very considerable time, during which respiration continued, and the results were not adequate for diagnosis. Theirs was an idea ahead of its time, but with 20 years of further advances in electrical and mechanical engineering, and in particular the development of multislice scanners and more sensitive radiation detectors, acquisition speeds have improved by several orders of magnitude. Achenbach described the first successful CT coronary angiography in 1998, using the same fundamental principle.4

The assessment of stenotic disease of the coronary arteries has primarily been performed by invasive catheter angiography (ICA), a technique which is remarkably safe, but has a small incidence of serious complications such as stroke, and which is inherently expensive. Subjective visual estimation of the degree of stenosis by the operator can be supplemented by measuring pressure gradients across lesions while using adenosine as a stressor agent. CT coronary angiography (CTCA) allows for a visual assessment only, and CT images have fundamental differences to those from invasive angiograms. Firstly, there is reduced spatial resolution, and smaller coronary vessels are therefore beneath the resolving power of CTCA. Secondly, areas of high radiographic density, such as the calcium in atheromatous plaques, appear larger in volume on a CT image than they really are, due to an artifact inherent in the image reconstruction, a phenomenon known as ‘blooming’. Thus the degree of stenosis on a CT image can be an overestimate compared to that found at ICA. Finally, ICA is performed after the administration of intracoronary nitrate as a vasodilator, whereas CTCA necessitates less effective sublingual nitrate.

These differences in the images obtained have led to the main use of CTCA being to exclude coronary artery disease in those thought to have a relatively low risk of such, in an elective setting. There is a large body of literature demonstrating that CTCA is extremely reliable in excluding significant coronary disease. Ellis et al describe exactly this usage, with the population under study reflecting the private practice setting. As the authors state, they do not have ICA correlation of their results in the patients without significant disease at CTCA. Advances in CT technology are so rapid that the 64-slice scanner used for their work, while state-of-the-art technology in 2006, would now be described as obsolete for cardiac imaging. In this context, their achievement of successful imaging of the entire coronary arterial tree in 95% of their patients is impressive, and a tribute to their attention to detail in scanning technique, and likely an appropriately conservative approach to patient selection. Continuing improvements in CT acquisition speeds have meant that patients previously regarded as unsuitable for CTCA on the grounds of irregular cardiac rhythms and...
relative tachycardia can often be imaged successfully now. Improvements in spatial resolution are reducing the effect of the blooming artifact from calcified plaques.

As CTCA has evolved since Achenbach, where will it fit in the diagnosis of coronary artery disease in the future? The SCOT-HEART trial\(^5\) offered CTCA in addition to standard cardiological assessment and investigation to a large number of patients with suspected angina in a high-risk population, and resulted in change of management in 27% of the subjects. Overall ICA usage increased because of patients previously considered not to need such who were found to have significant coronary disease at CTCA, and who outnumbered those patients whose ICA was cancelled after normal coronary arteries were found at CTCA. Thus ICA was used more appropriately. Stress studies were reduced in number, and diagnostic certainty and use of appropriate preventative therapies were increased in the CTCA group compared to the controls.

In New Zealand cardiological practice, CTCA is not used in this way as yet, and the number of invasive angiograms performed in patients with normal or near-normal coronary artery disease is now too high. Every week this author sits in the cardiosurgical case conference in our largest hospital and sees a number of patients referred for surgical treatment of cardiac valve disease. Those aged over 40 will have had their coronary arteries imaged, nearly all by ICA, and most have no significant coronary artery disease. If those patients alone had been referred for CTCA instead, the financial savings in the Auckland region public hospitals would be approx. $0.4 million a year. Cardiology is now the only medical specialty in which elective angiographic imaging is still performed predominantly by invasive means.

However, if more patients are to gain access to CTCA in future, then other changes are required. In New Zealand hospitals, all CT scanners are ‘owned’ by radiology departments, who have been reluctant to allow cardiology patients access to their facilities, though they are happy to use such to justify the purchase of very advanced and costly scanner technology. This is slowly improving, but there is still little if any access to CTCA outside ‘office hours’. Cardiac imaging is demanding on medical radiation technologists, and too few of the many CT-trained MRTs can perform cardiac imaging. Finally, medical educational authorities need to come to the party as well: there are relatively few medical practitioners skilled in CTCA interpretation. Training standards for Australasian cardiologists still require the performance of many catheter angiograms, but do not require the trainee to ever look at a cardiac CT or MRI scan, never mind actually perform or interpret one.

Technology will continue to evolve, and a fundamental redesign of the CT scanner to make it more suited for cardiac imaging in particular has recently been proposed.\(^6\) Prototype scanners capable of image acquisition in as little as 25–50ms are in design, and the advent of spectral imaging (the radiographic equivalent of splitting white light into its component colours) is likely to reduce contrast loads and radiation doses, which have already fallen significantly, even further. It may soon be possible to measure fractional flow reserve on CT images, thus allowing for assessment of the functional significance of an intermediate coronary lesion without the need for an invasive test.\(^7\) CT has revolutionised many medical specialities over the last four decades; cardiology may yet become one of them.

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