

# CT Perfusion Imaging: The Best of Both Worlds

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### Introduction

A few years ago, the idea of combining the spatial and temporal accuracy of CT with the recognised benefits of mapping regional perfusion for routine diagnosis was a dream. With the advent of wide-area detector CT that dream has become a reality.

The idea of assessing physiological phenomena using CT perfusion is not a new one with Leon Axel proposing a method for measuring cerebral blood flow just 8 years after Hounsfield introduced the first CT<sup>1</sup>. Because of technological limitations early attempts were largely confined to research studies of the brain and kidneys<sup>2</sup>. The introduction firstly of spiral and then multislice scanners has enabled assessment of perfusion in increasing volumes of tissue.

In the era of cerebral thrombolysis for acute cerebral ischaemia, perfusion imaging is gaining further impetus<sup>3,4</sup>. In this clinical setting, CT perfusion can provide crucial additional information to the standard brain scan and CT cerebral angiogram. The 16 cm detector of the Aquilion ONE provides sufficient coverage in a single rotation for many selected

organs in addition to the brain, such as heart and kidneys, but also for a significant portion of organs, including the liver and pulmonary circulation. CT lung perfusion imaging has in the past been proven in various research models<sup>5</sup>. Most recently, the power of CT lung perfusion imaging in early detection and quantification of lung diseases in human subjects was demonstrated in a study requiring central line injection and with limited z-axis coverage<sup>6</sup>.

Another recent application, using dual energy CT perfusion methodology, has been applied to the in vivo diagnosis of ground glass opacification and pulmonary embolism (PE)<sup>7-10</sup>. In the latter study, dual-energy CT was employed to detect and quantify perfusion defects, obstruction score and RV/LV ratio in acute pulmonary embolism in a single scan volume without the need for subtraction techniques which are prone to motion misregistration artefacts. Using dual energy this is possible by employing the material decomposition theory<sup>11</sup>. In this paper, we show that perfusion imaging can be considered as an excellent alternative diagnostic tool to dual energy.

It is well recognised that conventional CT pulmonary angiographic (CTPA) follow-up will underestimate the presence, size and significance of perfusion abnormalities as a cause for thromboembolic pulmonary hypertension. In the past, this diagnosis required scintigraphy as an additional test to provide this perfusion data<sup>12</sup>.

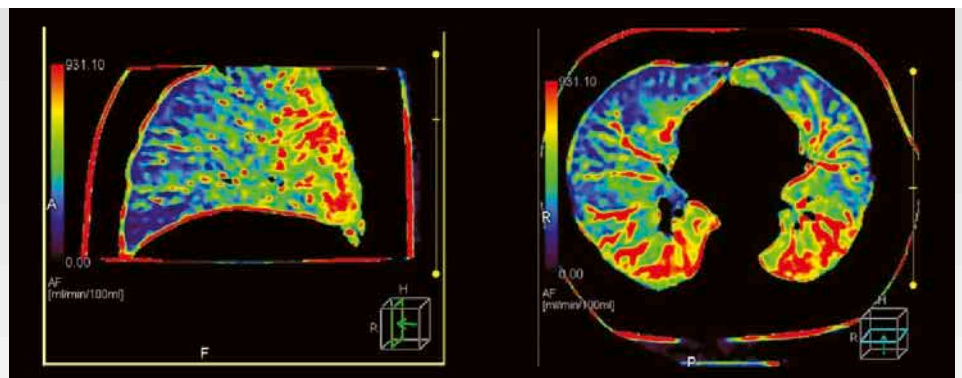
It is in the scenario of pulmonary embolism follow-up that our institution has initially explored the possibility of utilising the 16 cm z-axis coverage offered by Toshiba's Aquilion ONE to provide novel functional perfusion data and at the same time provide anatomical data on presence of residual thrombi.

### Technique

The CT perfusion technique uses a peripheral intravenous injection of 70 ml of iodinated contrast (Iomeron 400 mg I/ml, Bracco) followed by 30 ml saline flush at the same injection rate.

The scan range is set to 160 mm using intermittent dynamic volume acquisition with a low dose protocol of 100 kV, 100 mA, a 400 mm field of view and a rotation time of 0.5 s. Scans are obtained from 5 s to 20 s after start of injection at 2 s intervals.

Fig. 1: The perfusion maps in this patient with normal perfusion demonstrate the normal physiological gradient throughout the lung in a subject in the supine position. Note higher perfusion (warmer tones) in the more dependent portions of the lung.



This method is capable of yielding low-dose CT pulmonary angiography data in addition to providing the dynamic data required to obtain perform perfusion analysis.

### Initial results

Figure 1 shows a patient referred for possible hepato-pulmonary syndrome. The images clearly demonstrate the gravity-dependent perfusion as expected in a normal distribution pattern. The lung has relatively homogeneous perfusion in the non-dependent areas.

Figure 2 shows a patient who was evaluated three months after a large central pulmonary thromboembolic event. This patient was still on oral anti-coagulant therapy, but did not receive fibrinolytic therapy at the initial event. The study again demonstrates the gravity-dependent effects on the perfusion, but at the same time shows peripheral perfusion defects. The same study was evaluated for the presence of pulmonary embolism, which could not be demonstrated down to sub-segmental level. Based on this observation, it would appear that microvascular disease causes persistent perfusion abnormalities, and this could be a sign for the future development of long-term complications, such as chronic thromboembolic pulmonary hypertension.

### Conclusion

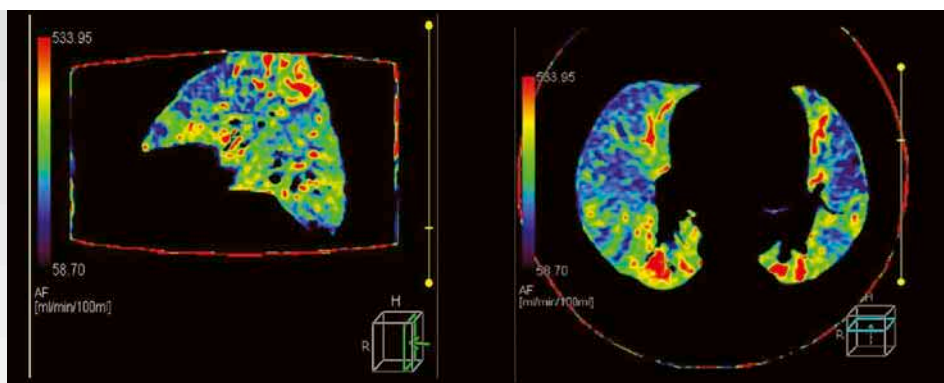
CT perfusion utilising wide-area coverage has the

potential to study physiological effects of lung and pulmonary vascular diseases. This work is to be expanded in the near future.

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Fig. 2: This patient, who previously sustained a massive pulmonary embolism, remained symptomatic 3 months after the initial event. Despite an apparently normal conventional CT pulmonary angiogram, there are areas of strikingly reduced perfusion in the infero-posterior regions of the lungs. Some of these areas demonstrate segmental distribution and are likely to represent chronic post-thrombotic occlusion.



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