PHILIPS

Computed Tomography

White paper

Cardiac imaging using Spectral detector CT

Purpose

Philips Spectral detector CT, the world's first and only detector-based spectral technology, is the only dual-energy solution that provides layers of spectral data without compromise. This paper demonstrates the use and performance of Spectral detector CT with Philips iPatient technology at a premier healthcare institution in China.

MDCT in cardiac imaging

The use of multi-detector CT (MDCT) for cardiac imaging has become more prevalent, making it the standard clinical test for a variety of cardiovascular conditions. With its high sensitivity and negative predictive value, cardiac CT has become the noninvasive modality of choice for the assessment of coronary artery disease (CAD) and its impact on cardiac function and perfusion.[1] Additionally, cardiac CT aids in the quantification of coronary plaque, the assessment of stents for in-stent restenosis, and the planning of complex coronary and structural interventions such as transcatheter aortic valve implantation (TAVI).

Challenges to cardiac imaging

There are multiple challenges in imaging coronary arteries. These arteries are typically small, with a caliber approaching 1 mm in size at their most distal ends. These small vessels exhibit complex 3D motion during the cardiac cycle, which is a major cause of artifacts during coronary imaging.[2,3] This requires MDCT scanners to have the speed necessary to capture cardiac anatomy, good spatial resolution to visualize the small structures of coronary arteries, and fast gantry rotation (i.e., excellent temporal resolution, which is critical to imaging moving structures).

Spectral detector CT in cardiac imaging

Spectral detector CT is built upon the iPatient platform. With enhanced spectral capabilities and fast rotation speed (0.27 sec, standard temporal resolution of 135 ms in Step & Shoot Cardiac with added improvements via adaptive multi-cycle reconstruction in helical), Spectral detector CT is ideally suited to address cardiac imaging challenges. Spectral results such as, but not limited to, monoenergetic (MonoE) and Iodine no Water, are always available either prospectively or retrospectively along with the standard conventional results.

Philips iPatient scanner platform

The Philips iPatient scanner platform enables users to achieve consistent cardiac image quality every day while managing dose appropriately. This dynamic user interface provides features that facilitate the use of patient-specific dose management tools for increased diagnostic confidence, while at the same time helping to improve workflow and efficiency with integrated functionality designed to enhance real-time decision-making.

Spectral CT vs conventional CT

In contrast to conventional results which represent polychromatic X-ray, MonoE results (also Hounsfield Unit [HU]-based) show attenuation as if a single monochromatic energy (keV) was used to scan. These results can be displayed in real time, representing 161 different single-energy levels between 40 and 200 keV. These MonoE results have multiple applications such as boosting of iodine signal (low MonoE), improvement of contrast-to-noise ratio (CNR) (low MonoE), and reduction in calcium blooming, beam hardening and metal artifact (high MonoE).

Unlike MonoE, which is an HU-based image, Iodine no Water is a material density image that represents the iodine component with the water component suppressed. The iodine content is shown within a Region of Interest (ROI) and reported in mg/ml. In general, while Iodine no Water is typically used to show iodine uptake, it has also been shown to enable assessment of the coronary arteries in the vicinity of calcium, while at the same time maintaining contrast enhancement in the lumen.

Spectral detector CT at PUMCH

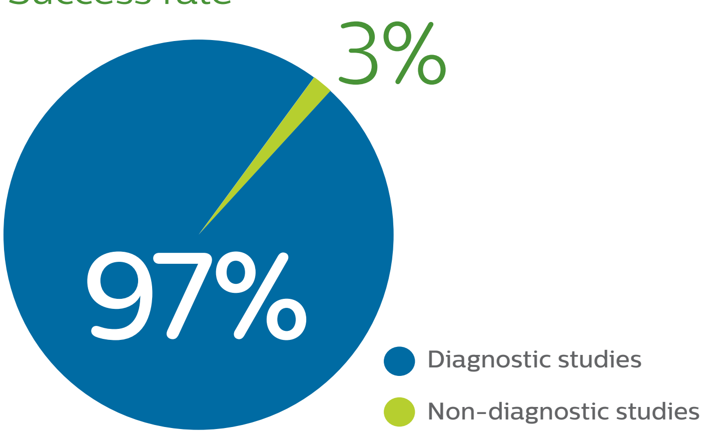
Peking Union Medical College Hospital (PUMCH, Beijing, China) was founded in 1921 by the China Medical Board. It is a Class A tertiary comprehensive hospital committed to delivering state-of-the-art clinical care, performing innovative scientific research and providing rigorous medical education. Designated by the National Health and Family Planning Commission as one of the national referral centers offering diagnostic and therapeutic care of complex and rare disorders, it is considered nationally a leader in diagnostic medical imaging. It maintains an excellent reputation for its full range of disciplines, cutting-edge technologies and outstanding specialties, consistently topping the "Best Hospitals in China" rankings since 2009.

As an early adopter of Spectral detector CT, PUMCH has gained a tremendous amount of experience in non-invasive cardiac imaging, having scanned more than 1,500 patients on Spectral detector CT. With the help of the dose management tools of the iPatient platform, scan and injection protocols were continuously adapted for patient body habitus (based on height, weight and body mass index [BMI]). Cardiac dose management tools such as Step & Shoot Cardiac and ECG-tube modulation in helical scans were employed for radiation dose optimization.

As part of planning the diagnostic scan, the water equivalent diameter (WED) was detected from the surview (scout) based on which the DoseRight index (DRI) was calculated to optimize the tube output (mAs) to deliver consistent image quality. The energy output of the tube was set to 120 kVp, with the mAs determined using the DRI based on the WED from the surview. Because spectral is always on, low MonoE spectral results were used to boost contrast enhancement. This allowed for cardiac CT scans to be performed at lower prescribed thresholds of contrast volume, with only 36 ml of contrast medium along with 20 ml saline chaser injected at a flow rate of 3 ml/sec. An automated bolus-tracking technique was used to start data acquisition, with scans triggered six seconds after a threshold of 90 HU was reached in the descending aorta.

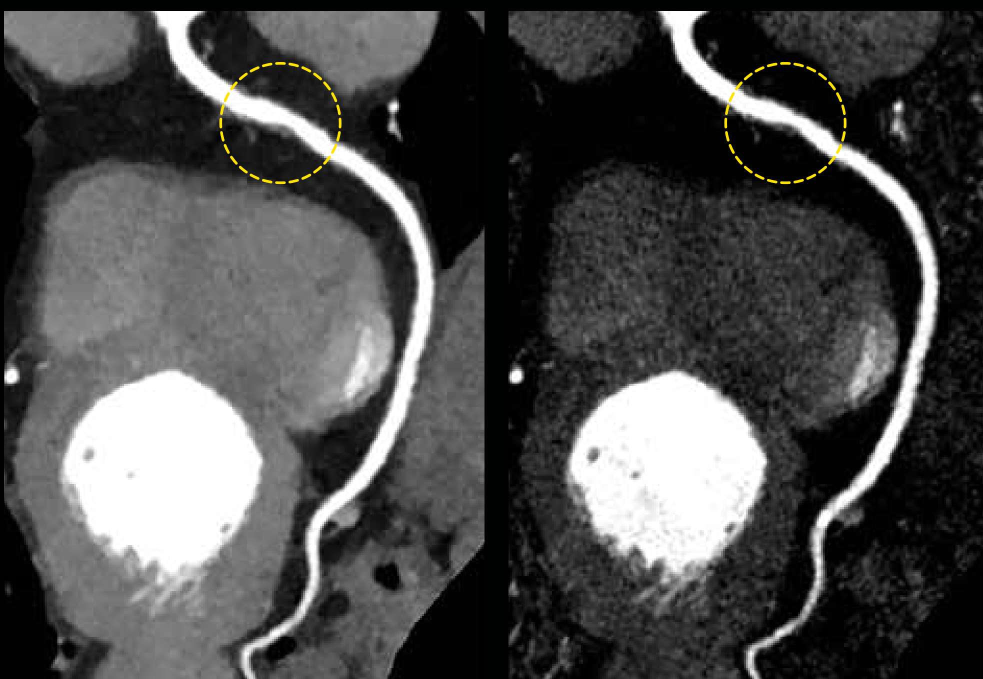
All scans were successfully performed, with a mean attenuation of 350 HU obtained in the aortic root (as measured with conventional results) across all cases. This value was further enhanced with the use of low keV MonoE spectral results (720 HU using 50 keV and 495 HU with 60 keV), which further helped with the coronary assessment. The optimized protocols resulted in coronary CTA scans of high quality, with 97% of the scans considered diagnostic. The reasons for non-diagnostic results are attributable to circumstances widely published in clinical literature (such as coronary motion).[4-6]

Success rate



Peking Union Medical College Hospital (PUMCH), Beijing, China

The **robust performance of the Spectral detector CT** for cardiac imaging is demonstrated via the following examples



Using the spectral Comprehensive Cardiac Analysis (sCCA) application on IntelliSpace Portal, spectral images such as MonoE 50 keV and Iodine no Water clearly demonstrate the small non-calcified plaque in the RCA.

Case study 1

This case study demonstrates the capability of Spectral detector CT in performing low-dose cardiac examinations. A middle-aged male patient on medication for suspected cardiac disease and complaining of occasional chest pain underwent coronary CT angiography (coronary CTA) using Step & Shoot Cardiac (effective dose: 0.85 mSv, k = 0.014)*. A total contrast volume of 30 ml was injected at 3 ml/sec. Using the spectral Comprehensive Cardiac Analysis (sCCA) application, available on IntelliSpace Portal, curved Multi-Planar Reformation (cMPR) images were generated using conventional and spectral results such as MonoE 50 keV for better visualization and characterization of structures based on spectral attenuation properties. A small non-calcified plaque was seen in proximal right coronary artery (RCA) that was well visualized using the MonoE 50 keV and Iodine no Water spectral results.

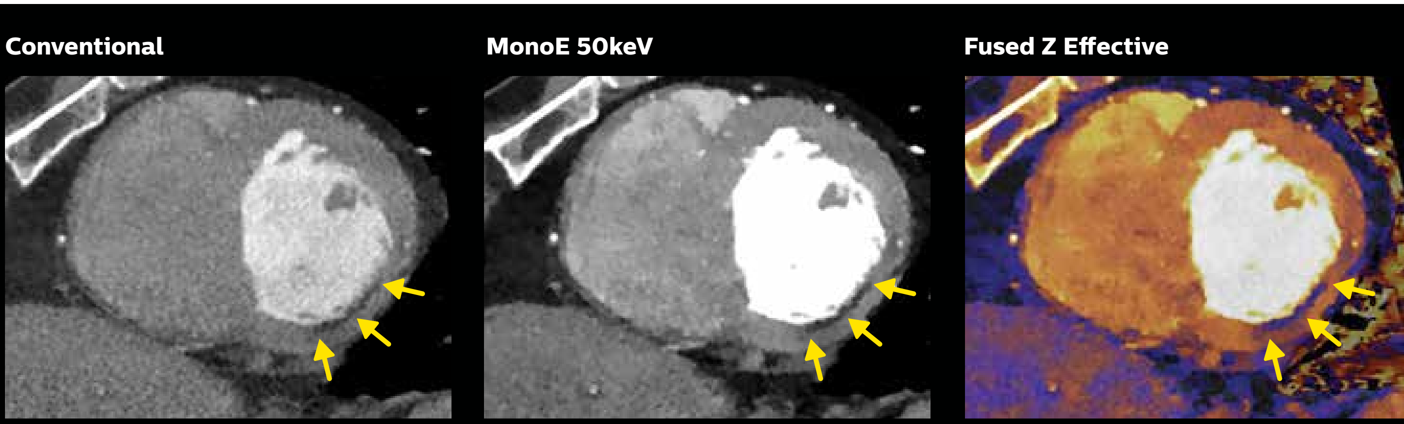
All images courtesy of Prof. Yining Wang and Prof. Zhengyu Jin, PUMCH.

*Using AAPM Technical Report 96.

Conventional images are inadequate for in-stent visualization, even after adjusting window width and level, with restenosis affected by stent blooming. High MonoE 150 keV effectively reduces blooming, low MonoE 50 keV improves vascular contrast, and Iodine no Water more clearly demonstrates the in-stent restenosis.

Case study 2

A middle-aged male patient with a history of hypertension and smoking complained of acute chest pain. His electrocardiogram (ECG) indicated myocardial infarction of the posterior wall and he underwent invasive coronary angiography with stents implanted in the RCA and the left circumflex (LCX). Because of recurring chest pain, he underwent coronary CTA using Spectral detector CT. cMPR images of the LCX in the stent region were reviewed using conventional and spectral results, using sCCA application on the IntelliSpace Portal. The ability to perform an assessment of the lumen within the stent was extremely limited using the conventional image in spite of adjusting the window and level. The high MonoE (150 keV) result reduced the blooming artifact arising from the struts of the stent but at the expense of decreased contrast enhancement. The low MonoE (50 keV) result provided the benefit of increased contrast enhancement, with some indication of low enhancement in the proximal area of the stent but accompanied by increased blooming off the stent. In contrast, the Iodine no Water image clearly showed a drop in the enhancement in the proximal end of the stent and with reduced blooming off the stent struts. Additionally, a review of the short-axis images showed the presence of sub-endocardial defect in the inferior and inferolateral walls of the myocardium (RCA and LCX territories), more clearly seen in the spectral results (low MonoE 50 keV), with the Z Effective image showing the relevant color map.



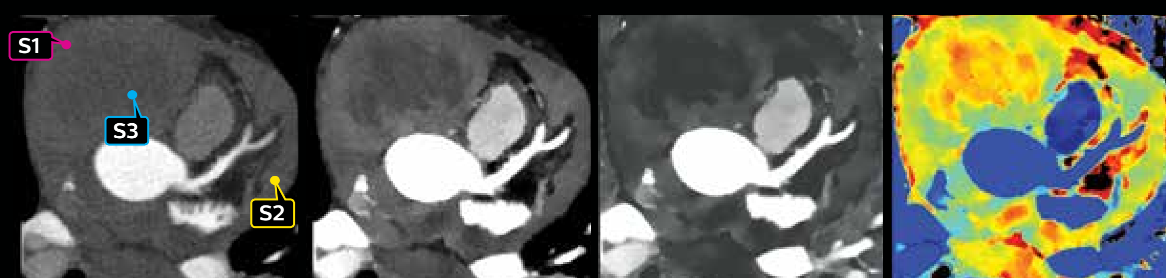
Conventional, MonoE 50 keV, and fused Z Effective short-axis images, with the spectral images more clearly showing the range of the myocardial perfusion defect.

Case study 3

A middle-aged female patient with a history of hypertension and symptoms of back pain and intermittent chest discomfort underwent a coronary CTA using Spectral detector CT for the evaluation of coronary arteries. All coronary artery segments were assessed, with an ostial lesion of the RCA found (as shown in the cMPR view). In addition, an irregular thickening of the pericardium was observed that included a large tumor occupying the mediastinal area. Spectral tools were very helpful in examining the heterogeneous composition of this pericardium-occupying mass. In contrast to the conventional image, spectral low MonoE (40 keV), Iodine no Water and Z Effective images provided better visualization of the hypodense core of this mass. Drawing ROI (S1, S2 and S3) in three different areas helped differentiate these areas further, with the pericardial muscle (S1, S2) showing an iodine uptake at low MonoE with the central region (S3) showing a downward slope (or no iodine uptake – indicating a necrotic core). Based on the findings, a CT-guided pericardiocentesis biopsy was performed along with immunohistochemical staining analysis, which confirmed the existence of mesothelioma.

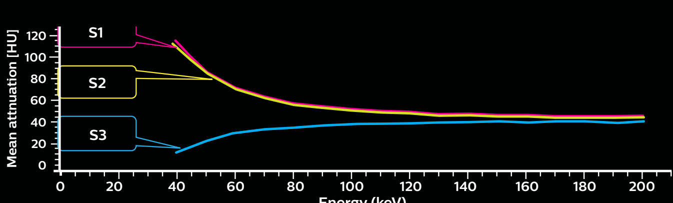
CMPR generated using the sCCA application on IntelliSpace Portal. Yellow circle indicates the ostial lesion of RCA.

Conventional **MonoE 40 keV** **Iodine Density** **Z Effective**

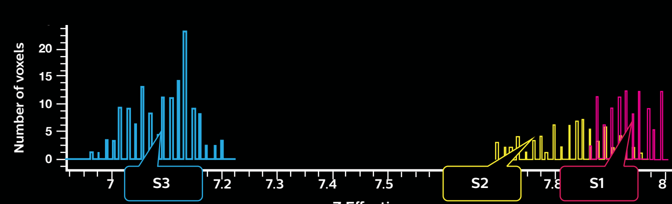


Conventional and spectral images (MonoE 40keV, Iodine Density and Z Effective). The spectral images more clearly demonstrate the composition of the mass along with its hypodense core. Also shown are spectral plots with regions of interest (S1, S2 and S3) in three different areas helping to differentiate these areas further.

HU attenuation plot



Histogram: Z Effective



Conclusion

Spectral detector CT results offer additional clinical insights for assessment of cardiac diseases. Spectral results such as MonoE and Iodine no Water improved visualization of complex cardiac structures compared to conventional images. The case examples shown here demonstrate the benefits of Spectral detector CT – with spectral information always available, prospectively and retrospectively.

Clinical relevance

Philips Spectral detector CT with iPatient technology improves diagnostic confidence in everyday clinical practice by enabling assessment of various cardiac diseases and their impact on function.

Results from case studies are not predictive of results in other cases; results in other cases may vary.

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