The spectrum of Cardiothoracic CT imaging – Case discussion with dual-source CT techniques.

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Introduction

Cardiovascular care and related imaging requirements have dramatically changed in the recent past. Historically, the standard was simple coronary imaging, which has progressively evolved to the demand for a broad spectrum of imaging techniques, including structural heart imaging (~160,000 transcatheter and LAAC procedures), heart failure imaging (~23 million patients), coronary artery imaging (~4,800,000 PCI procedures, ~7,000,000 diagnostic procedures), coronary artery imaging with variable heart rhythms (bradycardia, tachycardia, arrhythmia), pediatric cardiac imaging, thoracic vessel evaluation, ultra low dose lung cancer screening, 3D printing, photorealistic imaging, robotic, and surgical imaging.

Sophisticated imaging demands must be fulfilled to ensure a tailored diagnostic and clinical procedure and better patient outcomes.

Dual-source dual-energy systems revolutionized the field of cardiac imaging, in all its indications, by enabling native temporal resolution with sub-second scanning, thanks to the simultaneous maximum rotation speed at the highest pitch. This unparalleled technology can uniquely attain images confidently in the most challenging clinical conditions.

Scanning technique

Patients have been scanned on the Siemens Healthineers SOMATOM Force dual-source CT (DSCT) scanner equipped with the state-of-the-art AI-based advanced cardiac package, including adaptive perspective acquisition (CorAdSeq), adaptive retrospective modeling, prospective ECG-triggered sequence, and Turbo Flash protocols.

AI-based algorithms with DSCT techniques ensure the highest image quality with the lowest achievable dose. In addition, automatic exposure control for kV and mAs settings is the key to reducing contrast amount and dose on a patient-specific basis.

Case Study 1
Pediatric Congenital Anomaly Imaging

History and Impression

A pediatric patient presents for post-Fallot repair follow-up with a recommendation for no sedation and free-breathing imaging.

Evidence of residual infundibular pulmonary stenosis is observed. In addition, images demonstrate dilated central pulmonary arteries predominantly to the left side and dilated ascending aorta with a right-sided aortic arch.

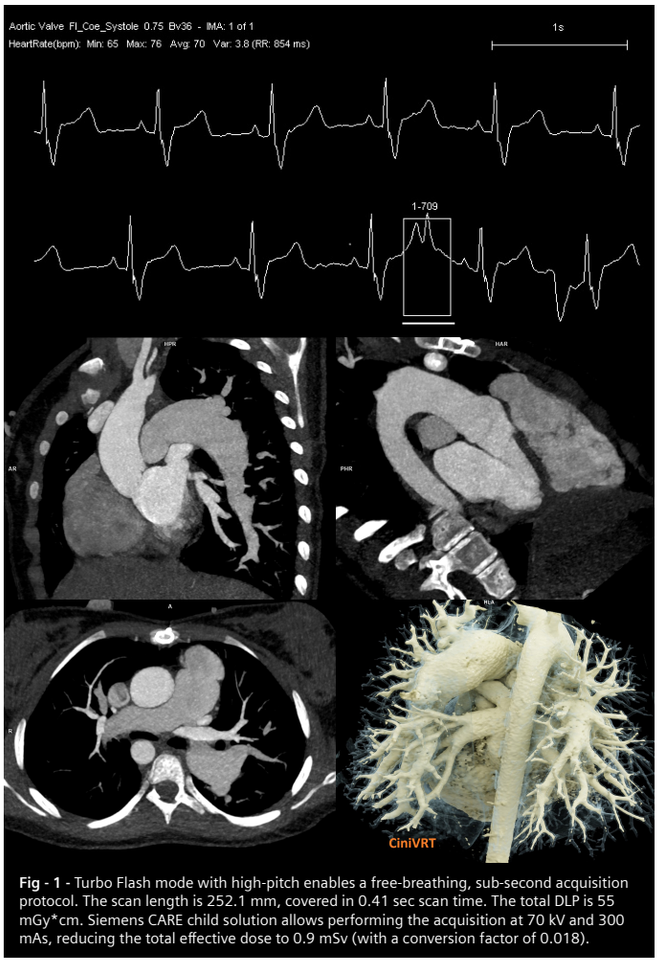

Fig - 1 - Turbo Flash mode with high-pitch enables a free-breathing, sub-second acquisition protocol. The scan length is 252.1 mm, covered in 0.41 sec scan time. The total DLP is 55 mGy*cm. Siemens CARE child solution allows performing the acquisition at 70 kV and 300 mAs, reducing the total effective dose to 0.9 mSv (with a conversion factor of 0.018).

Case Study 2
Single-Beat Atrial Fibrillation imaging

History and Impression

A patient suffering from hypertension presents to the emergency department with atypical chest pain and atrial fibrillation (irregular heart rate ranging from 55 to 103 BPM). A Turbo Flash-enabled, single-beat CT coronary angiography reveals normal coronary anatomy, with a nomenclature dominant RCA and a non-significant small myocardial bridging with the LAD.

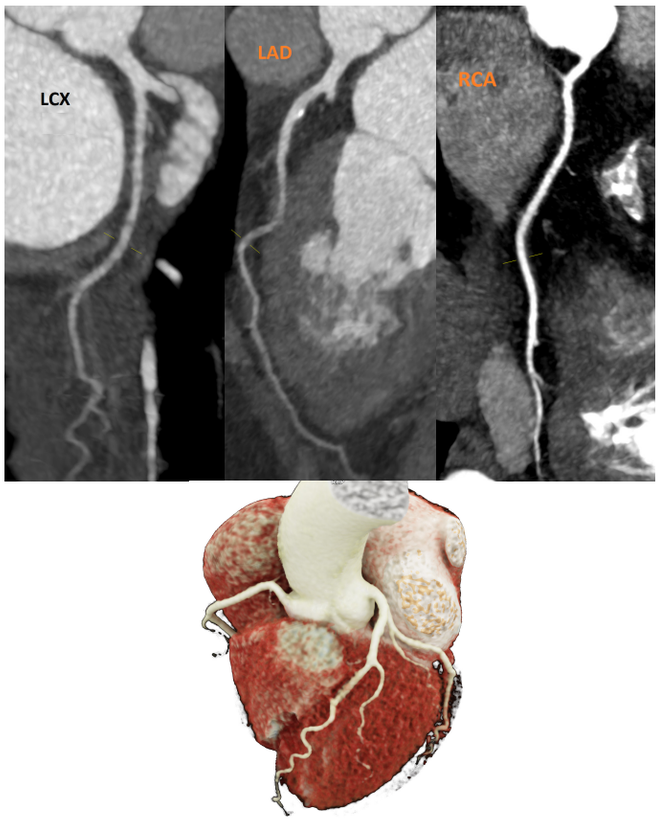

Fig - 2 - 40 ml of contrast media is injected at a rate of 5.5 ml/sec. A Turbo Flash, high-pitch, single beat sub-second acquisition is performed at a CT dose index of 1.62 mGy and a total DLP of 89 mGy*cm. The scan length is 150.9 mm, covered in 0.3 sec scan time. Siemens CARE Dose 4D and CARD kV solutions allow performing the study with low contrast medium volume at 70 kV and 405 mAs, reducing the total effective dose to 1.24 mSv (with a conversion factor of 0.014).

Case Study 3
Free-Breathing Pulmonary Emboli Imaging

History and Impression

A patient suffering from high blood pressure, diabetes mellitus, and with BMI of 33 presents with acute shortness of breath, tachycardia, and right lower limb edema. A venous doppler highlighted subacute deep vein thrombosis of the right LL. The CT scan visualized a saddle-shaped, massive pulmonary embolism.

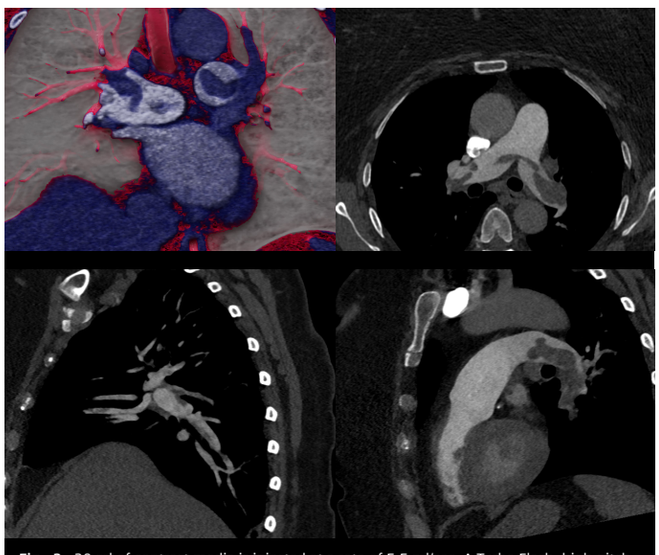

Fig - 3 - 30 ml of contrast media is injected at a rate of 5.5 ml/sec. A Turbo Flash, high-pitch, sub-second acquisition is performed at a CT dose index of 1.62 mGy and a total DLP of 89 mGy*cm. The scan length is 150.9 mm, covered in 0.3 sec scan time. Siemens CARE Dose 4D and CARD kV solutions allow performing the study with low contrast medium volume at 70 kV and 405 mAs, reducing the total effective dose to 1.24 mSv (with a conversion factor of 0.014).

Conclusion

Traditional CT coronary imaging gradually matured into comprehensive cardiac imaging protocols in the recent past with the support of emerging technologies. As a result, advanced CT cardiac imaging has developed into the preferred test used to diagnose various heart conditions, thanks to its noninvasive nature and absence of a recovery time.

The non-invasive, high-quality depiction of cardiac anatomy and pathology is no longer an excellent challenge for computed tomography. Intrinsic temporal resolution, high pitch, and dual-source technology, with its fastest rotation time, allow us to perform cardiac imagining without any physiological limitations. In addition, dual-source CT technological development, including hardware and AI-based software solutions, allows for overcoming the past challenges of comprehensive cardiac computed tomography imaging.

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Reference

1. Husmann L., Valenta I., Gaemperli O., Adda O., Treyer V., Wyss C.A. Feasibility of low-dose coronary CT angiography: first experience with prospective ECG-gating. Eur Heart J. 2008;29:191–197.
2. Herzog B.A., Wyss C.A., Husmann L., Gaemperli O., Valenta I., Treyer V. First head-to-head comparison of effective radiation dose from low-dose 64-slice CT with prospective ECG-triggering versus invasive coronary angiography. Heart. 2009;95:1656–1661.
3. Achenbach S., Marwan M., Ropers D., Schepis T., Pflederer T., Anders K. Coronary computed tomography angiography with a consistent dose below 1 mSv using prospectively electrocardiogram-triggered high-pitch spiral acquisition. Eur Heart J. 2010;31:340–346.
4. Alkadhi H., Stolzmann P., Desbiolles L., Baumueller S., Goetti R., Plass A. Low-dose, 128-slice, dual-source CT coronary angiography: accuracy and radiation dose of the high-pitch and the step-and-shoot mode. Heart. 2010;96:933–938.
5. Stolzmann P., Goetti R.P., Maurovich-Horvat P., Hoffmann U., Flohr T.G., Leschka S. Predictors of image quality in high-pitch coronary CT angiography. Am J Roentgenol. 2011;197:851–858.
6. Leipsic J., LaBounty T.M., Heilbron B., Min J.K., Mancini G.J., Lin F.Y. Adaptive statistical iterative reconstruction: assessment of image noise and image quality in coronary CT angiography. Am J Roentgenol. 2010;195:649–654.
7. Halliburton SS, Tanabe Y, Partovi S, et al. The role of advanced reconstruction algorithms in cardiac CT. Cardiovasc Diagn Ther 2017;7:527-38. 10.21037/cdt.2017.08.
8. Jiang H. Computed Tomography: Principles, Design, Artifacts, and Recent Advances. Bellingham: Society of Photo Optical, 2015. [Google Scholar]
9. Yang J, Yang X, De Cecco CN, et al. Iterative reconstruction improves detection of in-stent restenosis by high-pitch dual-source coronary CT angiography. Sci Rep 2017;7:6956. 10.1038/s41598-017-07499[PMC free article] [PubMed] [CrossRef] [Google Scholar]
10. Schindler A, Vliegenthart R, Schoepf UJ, et al. Iterative image reconstruction techniques for CT coronary artery calcium quantification: comparison with traditional filtered back projection in vitro and in vivo. Radiology 2014;270:387-93. 10.1148/radiol.13130233 [PubMed] [CrossRef] [Google Scholar]
11. Willemink MJ, Takx RA, De Jong PA, et al. The impact of CT radiation dose reduction and iterative reconstruction algorithms from four different vendors on coronary calcium scoring. Eur Radiol 2014;24:2201-12. 10.1007/s00330-014-3217-7 [PubMed] [CrossRef] [Google Scholar]

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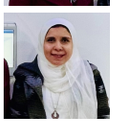

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