JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

THE ROLE OF THE WIDE DETECTOR IN THE TOMOGRAPHIC STUDY OF THE HEART

Marco Coda[1]; Fabio Grazioli[1]*; Oliviero Caleo[1]; Francesco Alfano[2]

1. *Diagnostic Imaging Department, AOU "San Giovanni di Dio e Ruggi D'Aragona", Salerno (Italy)*
2. *Freelancer*

* *Corresponding author fabiograzioli11@gmail.com*

KeyWords:
Cardio-CT, cardiovascular disease, Volume Rendering (VR), Electrocardiogram (ECG)

Abstract

Cardio-CT is a noninvasive diagnostic investigation capable of quickly and accurately obtaining detailed information about the heart chambers and coronary circulation.
The examination is characterized by high sensitivity and specificity in the identification of coronary artery stenoses, the main contributors to ischemic heart disease. Thanks to modern multi-detector CT equipment, the examination enjoys high resolution spatial and temporal, which is of paramount importance considering myocardial kinetics. Referring to the ESC 2019 guidelines, cardio-CT appears to be indicated in symptomatic patients with intermediate cardiovascular risk. Continued technological developments, resulting in the ability to obtain diagnostic images even in difficult patients such as those with irregular rhythm, tachycardia, and extensive calcifications, suggest future use of this technique even in selected cases of high-risk patients.

INTRODUCTION

Cardiovascular disease is the leading cause of death in Italy and the remaining part of the Western world. Ischemic heart disease and myocardial infarction are often caused by the presence of atherosclerotic plaque in one or more arteries. The presence of plaque in a coronary artery causes narrowing of the lumen and a consequent reduction in blood flow. This gave rise to the need for a rapid, practical and noninvasive examination such as Cardio-CT.
In 2000, the first CT scan of the myocardium was performed using equipment equipped with 16 rows of detectors. To date, this examination is performed using equipment with at least 64 layers. A greater number of layers corresponds to a greater body segment scanned in the unit of time. In other words, the presence of a large sensitive surface area greatly reduces scanning times, especially in an examination where physiological dynamics, such as heartbeat, must be considered.
The first equipment to make it possible to study coronary arteries was the multilayer CT scan (CTMS).
But it is only with the advent of newer generations of TCMS (>64 detectors) that there has been an improvement in spatial resolution (more sensitive detectors, better performing X-ray tubes) and temporal resolution (increased speed of rotation of the X-ray tube).
All of this has allowed for better anatomical detail of vascular structures, so much so that cardio-CT has become the noninvasive method with the highest diagnostic accuracy for the exclusions of significant coronary stenosis, and is the benchmark for other noninvasive methods. A further improvement concerning this diagnostic procedure, and especially the temporal resolution, has been made by dual source scanners (Dual source-CT), introduced in 2005. These are tomographers having two X-ray tubes, both opposed to a detector block, arranged at 90° to each other. The two tubes emit radiation simultaneously, so the scanning time is greatly reduced; a complete section is thus acquired in half a rotation. The techniques used for trans-catheter tricuspid valve surgeries are rapidly evolving, and imaging solutions are therefore increasingly needed to carefully assess valve anatomy and right ventricular function, especially in patients at high surgical risk. Dual Source CT allows accurate assessment of more complex valves due to its temporal resolution.

MATERIALS METHODS

Performing a Cardio CT involves the presence of a multislice CT (64>) and an ECG device; in fact, "Gating" is used, which is the function of synchronizing electrocardiographic activity to the scan. There are two types of Gating: Retrospective and Perspective. Using the former, we acquire images over the entire ECG cycle, then resort to reconstructions, while the latter allows for localized scans in a precise interval of the ECG. Prospective and retrospective studies are carried out at Azienda Ospedaliera San Giovanni di Dio e Ruggi D'Aragona, and a 256-slice G.E. Revolution CT

ESSAY

Citation:
M.Coda et al.
"The role of the wide detector in the tomographic study of the heart "

JAHC Essay 2024

Received: 29-12-2023
Revised: 09-01-2024
Accepted: 23-01-2024
Published: 06-02-2024

is currently in use. Although retrospective gating delivers a relatively higher dose than prospective, it still remains frequently used because it provides a greater diagnostic safety range in patients with high frequency and/or adverse conditions (Fig.1).
It turns out to be of considerable importance to use wide detectors, equal to 16 centimeters along the longitudinal axis, so that the entire cardiac surface is detected in the time of a single beat (Fig.2).
The examination involves the use of organo-iodine contrast medium, so the two main contraindications are high creatinemia values and pregnancy or lactation status. After venous access and electrodes are applied, the patient is instructed about apnea to be held during the examination and about the sensation of heat resulting from contrast.
If the rate is above 70 bpm, bradycardizing medication should be administered.
The precontrastographic scan is not always necessary; it is called "Calcium score" because it gives the percentage of calcium at the level of the coronary arteries; in fact, in front of high calcium levels the examination loses significance, since calcium has similar density values to mdc.
The diagnostic scan is the contrastographic scan, lasting only a few seconds.
The Field of View extends from the carina to the diaphragm.
Curvilinear reconstructions (Fig. 3) and VR Volume Rendering (Fig.4 and 5) are performed.
Based on our extensive experience in the field of cardiovascular imaging, review of recent technical and clinical literature in the area of the latest technological developments in the field of CT, and the current state of the art of commercially available CT equipment, the CT equipment of interest must meet the following technical requirements:

- **Temporal Resolution**: Currently, one must consider as effective temporal resolution the minimum time required in CT hardware to generate a single image; in single-source equipment this time is the time required to travel/acquire 180° of gantry rotation (i.e., tube/detector system) while in dual-source equipment it is the time required to travel/acquire approximately 90° of gantry rotation (i.e., tube/detector system). CT equipment currently on the market manages in some cases to achieve effective time resolution values in hardware of 66ms. This level of performance should be considered the benchmark. Given that temporal resolution is an essential parameter to be able to perform cardiac investigations in complex patients with suboptimal heart rates (tachycardic, arrhythmic, pediatric) for other equipment, a value approaching this benchmark is required, even with different hardware technology solutions.
- **Spatial resolution**: At present, the highest le-

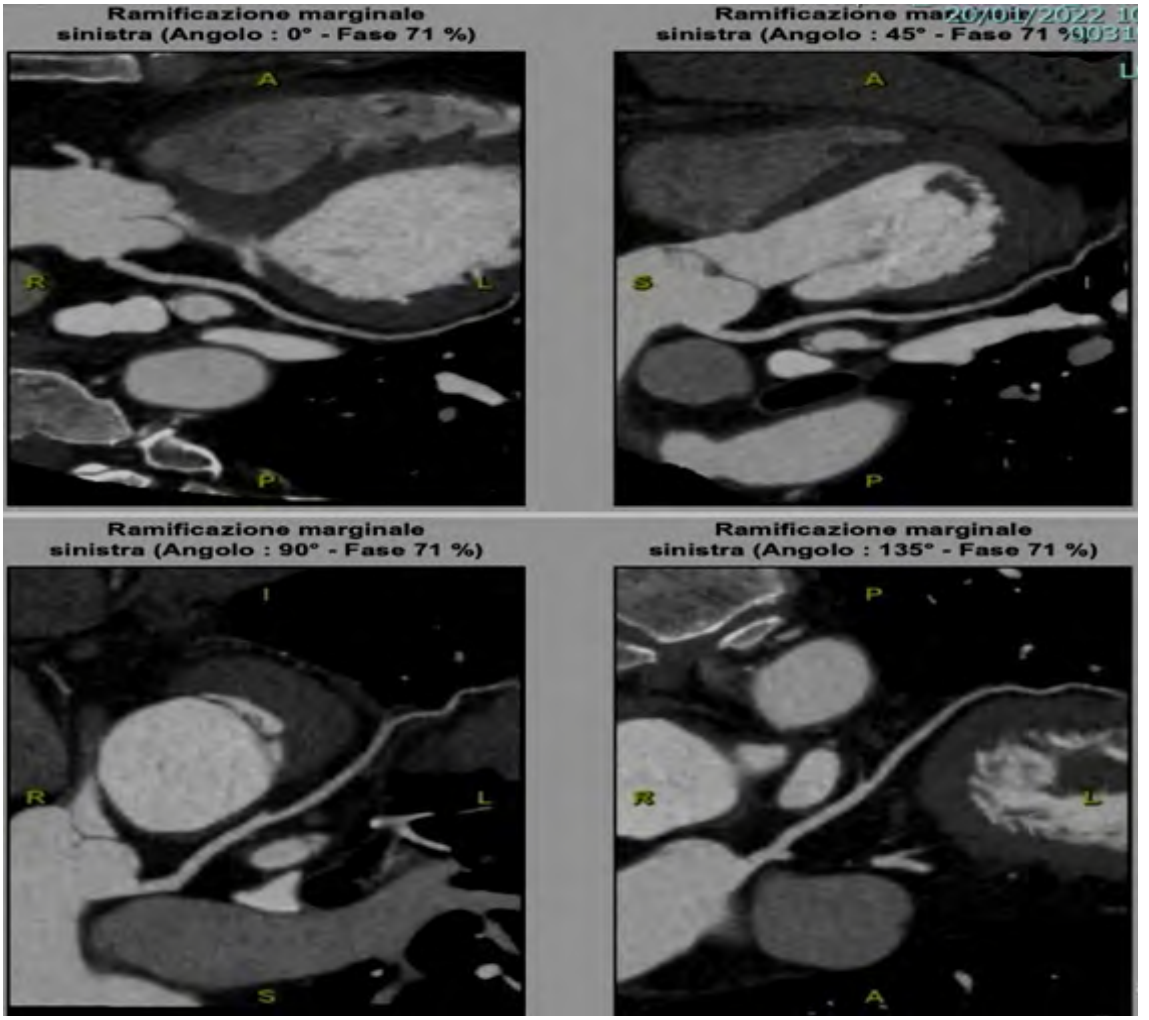

Fig. 1 Images acquired by retrospective technique

ESSAY
JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

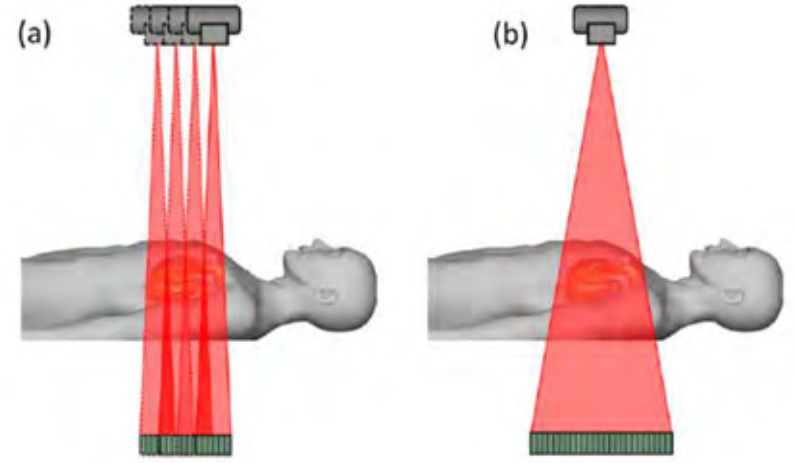

Fig. 2
System with large detector

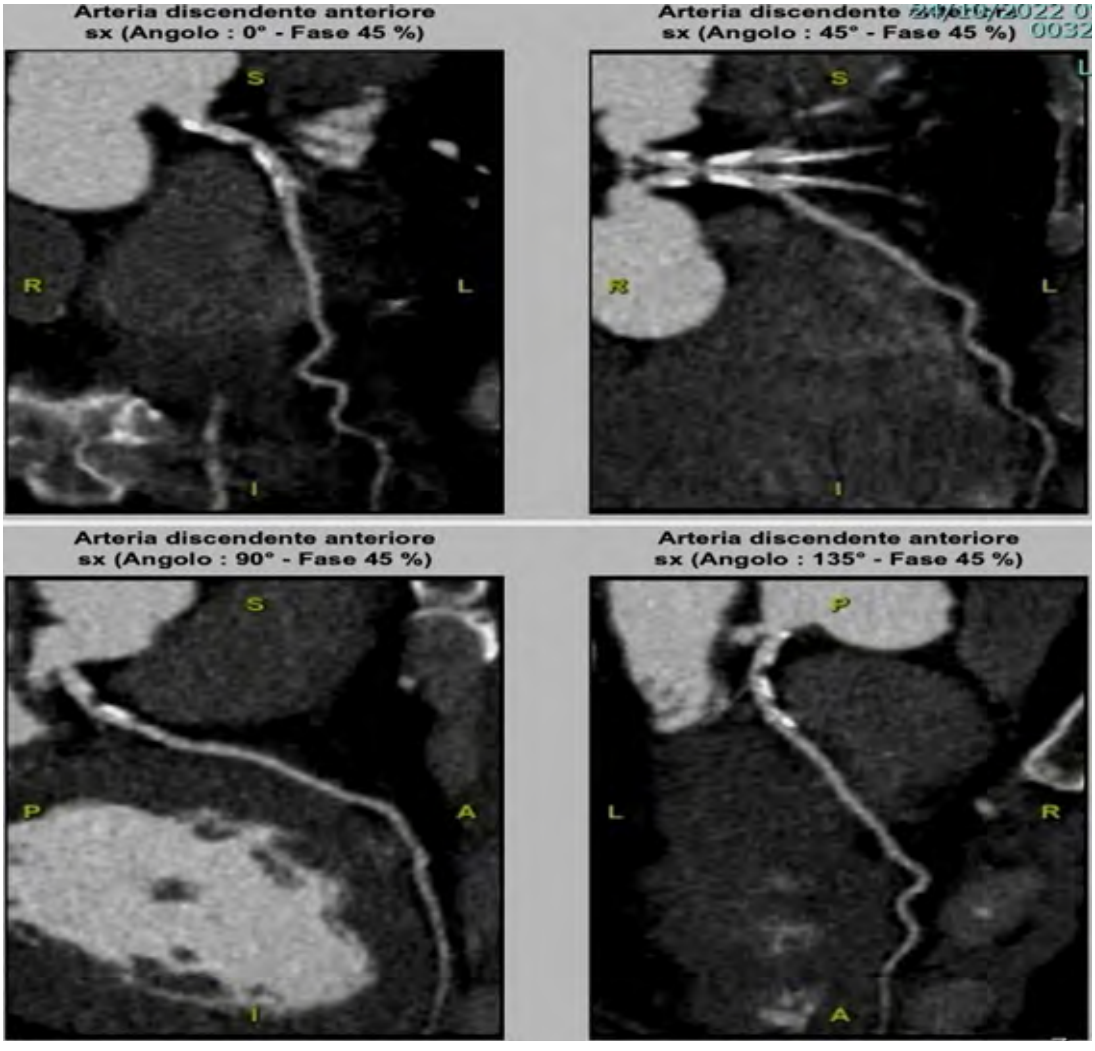

Fig. 3. Curvilinear reconstruction of the anterior descending artery

vel of spatial resolution achievable in CCT is a nearly isotropic voxel (in the x-y plane equal to 0.20-0.25mm; in the longitudinal-z axis equal to 5mm) that mainly suffers from asymmetry in the z-longitudinal axis since the minimum thickness on state-of-the-art equipment is 0.5mm. This spatial resolution is insufficient to robustly arrive at submillimeter features of the coronary plaque and myocardial tissue: therefore, the provision of equipment with significantly higher spatial resolution characteristics than the current ones is required, i.e., effective layer thicknesses <0.5mm even with reconstruction matrices >512x512 without post-acquisition interpolation (i.e., matrix >512x512 in the raw data). In the x-y plane, the spatial resolution must be <0.2mm.

- **Contrast resolution/spectral and multienergy imaging**: Contrast resolution is a key element of the ability to distinguish low-contrast structures with CCT. State-of-the-art CT detector technology, in addition to minimizing issues related to detector noise, enables what is known as "Photon

JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP
ESSAY
Citation:
M.Coda et al.
"The role of the wide detector in the tomographic study of the heart "
JAHC Essay 2024
Received: 29-12-2023
Revised: 09-01-2024
Accepted: 23-01-2024
Published: 06-02-2024

Counting," which is the ability of the detector to count the photons incident on the detector and assign the corresponding energy (kiloVoltage) to each. The advantage of this approach is that imaging becomes multi-energy detector-based and that it allows for more than 2 energy spectra sampling. Considering, also, that this technology opens up fields of research on nanoparticles based on other metals such as gold, tungsten (i.e., materials with k-edge between 30-110kV) that open up investigative possibilitiès in new contrast agents for atherosclerosis to be translated into the clinical setting, this technological requirement is requested.

- **Radiation dose:** Taking into account the performance described above, it is specified that the enhancement should be at least with the same radiation dose for a current state-of-the-art equipment (see above); however, a substantial/further reduction in radiation dose is desirable, at the samè of other parameters compared to current state-of-the-art equipment.

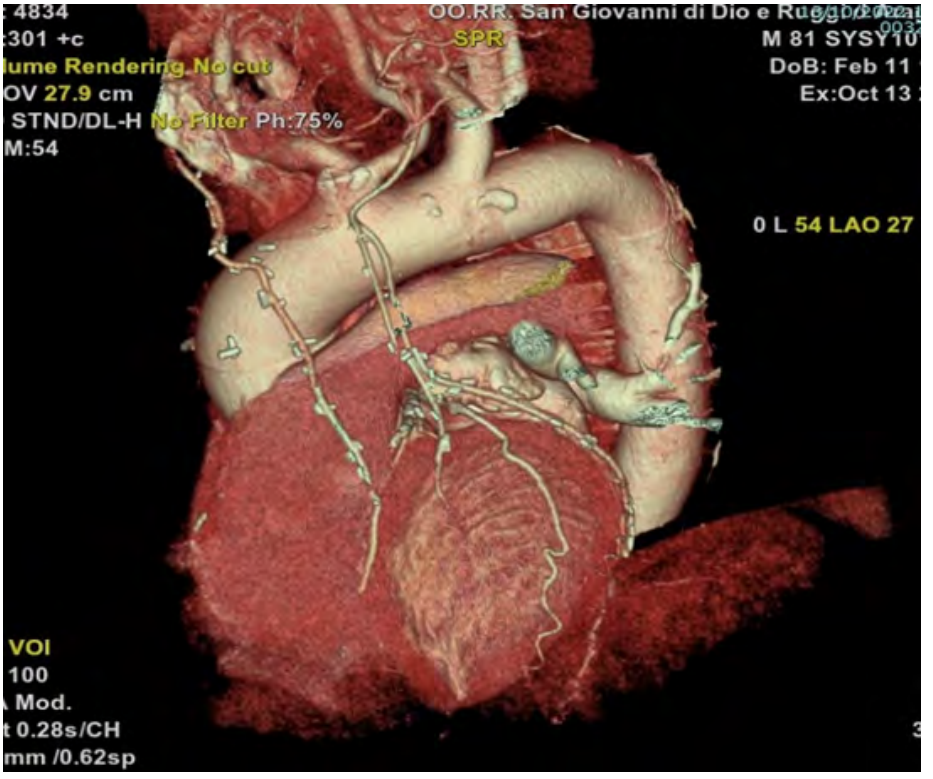

Fig. 4. VR Reconstruction of the Myocardium

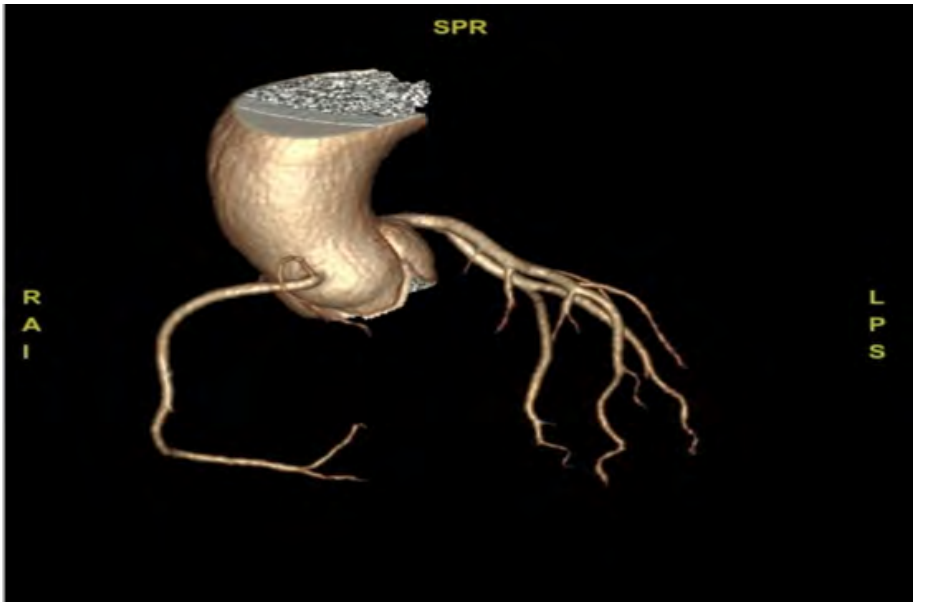

Fig. 5. VR reconstruction of vessels

ESSAY
JAHC | JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

CONCLUSIONS

Continuous innovation in equipment has made CT for the study of the heart a practical, comprehensive and, above all, particularly rapid and economical investigation when compared with other methods such as: Cardiac MRI and Myocardial Scintigraphy. The availability of CT equipment having a large detector has concretized the possibility of performing the entire scan in a single heartbeat, lowering the difficulty of having to join several cardiac segments acquired over several beats; an arduous task in tachycardic or arrhythmic patients.

BIBLIOGRAPHY

1. M.R. Andrea Laghi, La Cardio TC, Milano: Springer Verlag, 2012.
2. R. Fattori, La TC multidettettore nella diagnostica cardiovascolare, Milano, Italia: Springer Verlag, 2007.
3. Young Joo Suh "Tricuspid annular diameter and right ventricular volume on preoperative cardiac CT can predict postoperative right ventricular dysfunction in patients who undergo tricuspid valve surgery" Pub Med, 2019.
4. Go Hashimoto 1, "Essential roles for CT and MRI in timing of therapy in tricuspid regurgitation" Pub Med, 2019;
5. D. N. E. Caramella, "Tesi di laurea Ottimizzazione dell'Esame di Coronaro TC" 2015 [online] Avaiable: https://core.ac.uk/download/pdf/79619653.pdf.
6. Cardiac CT: current practice and emerging applications Subhi J Al'Aref1, Correspondence to Dr James K Min, Radiology, Weill Cornell Medical College, New York City, NY 10065, USA;
7. National Institute for Health and Care Excellence updates the stable chest pain guideline with radical changes to the diagnostic paradigm Adam Timmis et al., Heart, 2017;
8. The challenge of asymptomatic coronary artery disease in aircrew; detecting plaque before the accident, Gary Gray et al., Heart, 2019
9. Gibilaro , G. (2023). Cardiac CT: State of the art and future scenarios. Journal of Advanced Health Care, 4(3). https://doi.org/10.36017/jahc202243223

JAHC JOURNAL OF ADVANCED HEALTH CARE
OFFICIAL JOURNAL OF TSRM PSTRP

ESSAY

Citation:
M.Coda et al.
"The role of the wide detector in the tomographic study of the heart "

JAHC Essay 2024

Received: 29-12-2023
Revised: 09-01-2024
Accepted: 23-01-2024
Published: 06-02-2024