Clinical Case Collection

Dual Source Cardiac Imaging

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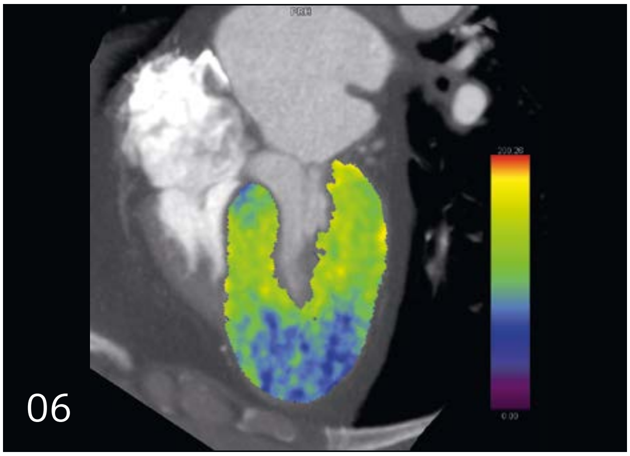

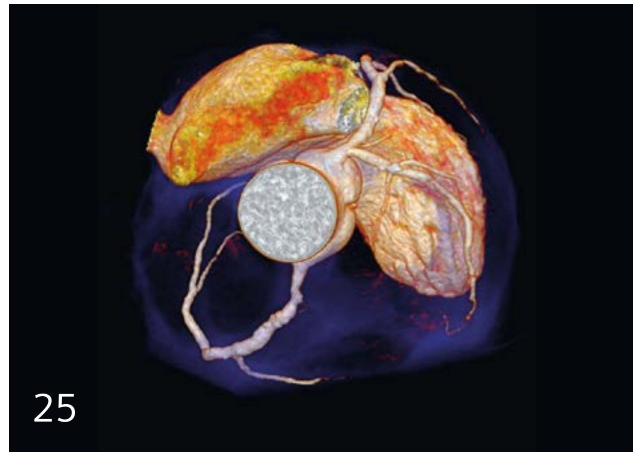

Coronary Artery Disease

Congenital Heart Disease

Myocardial hypoperfusion caused by severe coronary stenosis – revascularization?

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History

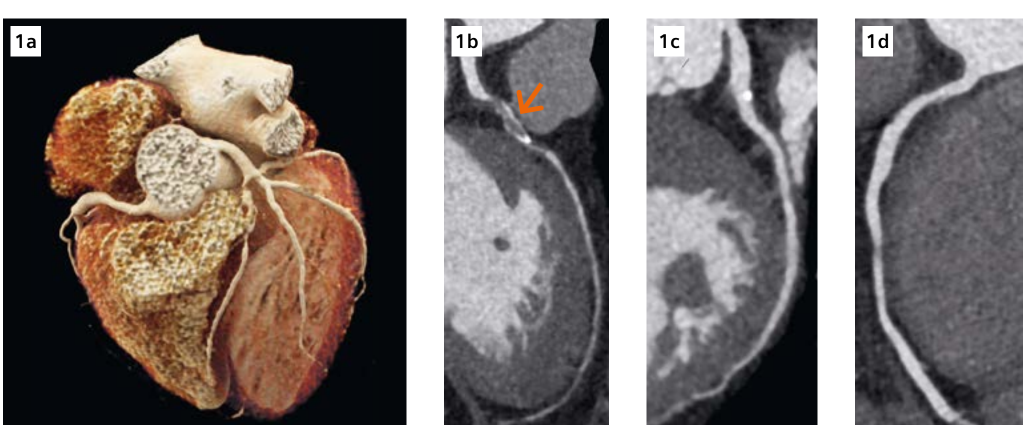
A 53-year-old male patient, a smoker, suffering from exertional chest pain for the past 4 months, came to the hospital for a check-up. His medical history included type 2 diabetes and hyperlipidaemia. Coronary CT angiography (CTA) was performed, followed by a dynamic CT myocardial perfusion imaging (MPI) in rest and under stress using adenosine-mediated vasodilation.

Diagnosis

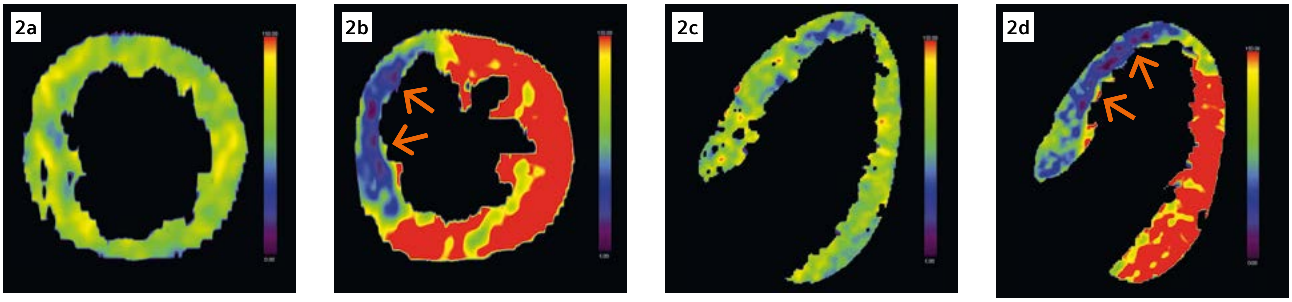
Coronary CTA images showed a right coronary artery (RCA) dominant system as well as a severe stenosis in the proximal left anterior descending artery (LAD), caused by both calcified and non-calcified plaques. No significant stenosis could be visualized in the circumflex (Cx) and RCA (Fig. 1). MPI in rest showed no perfusion abnormalities in the myocardium with a normal myocardial blood flow (MBF) of 95 mL/100 mL/min. MPI under adenosine-induced vasodilation showed a typical increase of MBF in remote areas (165 mL/100 mL/min), while there were large anterior and septal defects with a significant reduction of MBF (65 mL/100 mL/min) and reduced wall thickening corresponding to severe hypoperfusion; MBF was lower than in rest (Fig. 2). The normal MPI findings in rest indicate that there was no irreversible tissue damage yet, the pronounced MBF reduction under stress is consistent with the exertional chest pain of the patient. Subsequently, the patient underwent percutaneous coronary intervention (PCI), which confirmed the CT findings and successfully restored perfusion (Fig. 3).

Comments

The unique advantage of dynamic CT MPI is the potential of combining it with coronary CTA so that coronary artery stenoses and their effects on myocardial perfusion can be assessed comprehensively and noninvasively with a single modality.[1]
A systolic ECG-triggered Sequential Shuttle mode is used with an absolute delay of 250 ms, which is insensitive to extra-systolic events and improves myocardial perfusion evaluation since the myocardium is thicker in systole. It is also very robust for high and varying heart rates which are common in severe cases; in this patient the heart rate varied from 65 to 105 bpm over both examinations.
Quantitative myocardial perfusion CT is performed using dynamic CT scanning with contrast agent; stress is induced by adenosine-mediated vasodilation. Voxel time-attenuation curves are measured as the contrast agent passes through the heart. Perfusion parameters, such as MBF, are calculated from them using a deconvolution

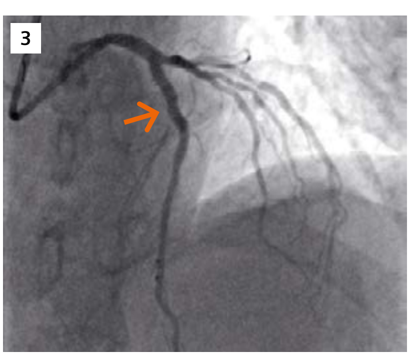


1 Cinematic VRT (Fig. 1a) and curved MPR (Figs. 1b–1d) images show a severe stenosis in the proximal LAD (Fig. 1b, arrow) caused by both calcified and non-calcified plaques. No significant stenosis can be visualized in the Cx (Fig. 1c) and RCA (Fig. 1d).



2 MBF images in both short (Figs. 2a and 2b) and long (Figs. 2c and 2d) axis reveal large anterior and septal defects under stress (Figs. 2b and 2d, arrows), and no perfusion defect in rest (Figs. 2a and 2c). Compared to a normal MBF of 95 mL/100 mL/min in rest, MBF under stress is significantly reduced to 65 mL/100 mL/min in the affected areas and increased to 165 mL/100 mL/ min in the remote areas.

algorithm.[2] CARE Dose4D (Real time Anatomic Exposure Control) is routinely applied to minimize radiation exposure. If a severe coronary stenosis with significant perfusion defects in its territory under stress is detected, it is still important for therapy selection to have information concerning tissue viability: Are there areas that are already irreversibly damaged? Therefore, in selected cases it is helpful to also include a rest MPI scan, which is not routinely done when there are no concerns related to fixed perfusion abnormalities. A valid alternative to a rest perfusion scan is a late enhancement scan aimed at the visualization of myocardial scarring. In this case, MPI performed in rest was normal, which made the presence of infarcted scar tissue in the affected areas unlikely. It is noteworthy that this patient had no coronary flow reserve for the LAD territory, as MBF was reduced below rest values by a "steal effect" from the remaining myocardium as a consequence of adenosine-mediated vasodilation. ●



3 A post-PCI image show a well recanalized LAD in the proximal segment (arrow).

Examination Protocol

Scanner	SOMATOM Force	
Scan area	Heart	Heart
Scan mode	Prospective ECG triggered CTA	Dynamic perfusion (Stress / Rest)
Scan length	116 mm	105 mm
Scan direction	Cranio-caudal	Shuttle
Scan time	3.7 s	32 s
Tube voltage	80 / 80 kV	70 / 70 kV
Effective mAs	438 mAs	341 mAs
Dose modulation	CARE Dose4D	CARE Dose4D
$CTDI_{vol}$	6.42 mGy	53.35 mGy (13 sweeps) 41.1 mGy (10 sweeps)
DLP	75.1 mGy*cm	563.4 / 434.0 mGy*cm
Rotation time	0.25 s	0.25 s
Slice collimation	152 × 0.6 mm	192 × 0.6 mm
Slice width	0.75 mm	3.0 mm
Reconstruction increment	0.5 mm	2.0 mm
Reconstruction kernel	Bv40 (ADMIRE 2)	Qr36
Heart rate	62–68 bpm	88–105 / 65–85 bpm
Contrast	300 mg/mL	300 mg/mL
Volume	60 mL	60 mL
Flow rate	7.5 mL/s	7.5 mL/s
Start delay	Test bolus using 15mL + 40 mL saline	Test bolus using 15 mL + 40 mL saline

References

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Apical hypertrophic cardiomyopathy

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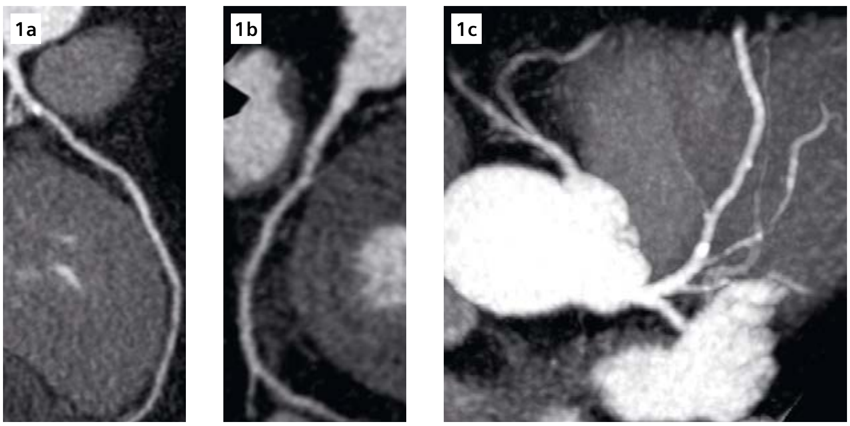
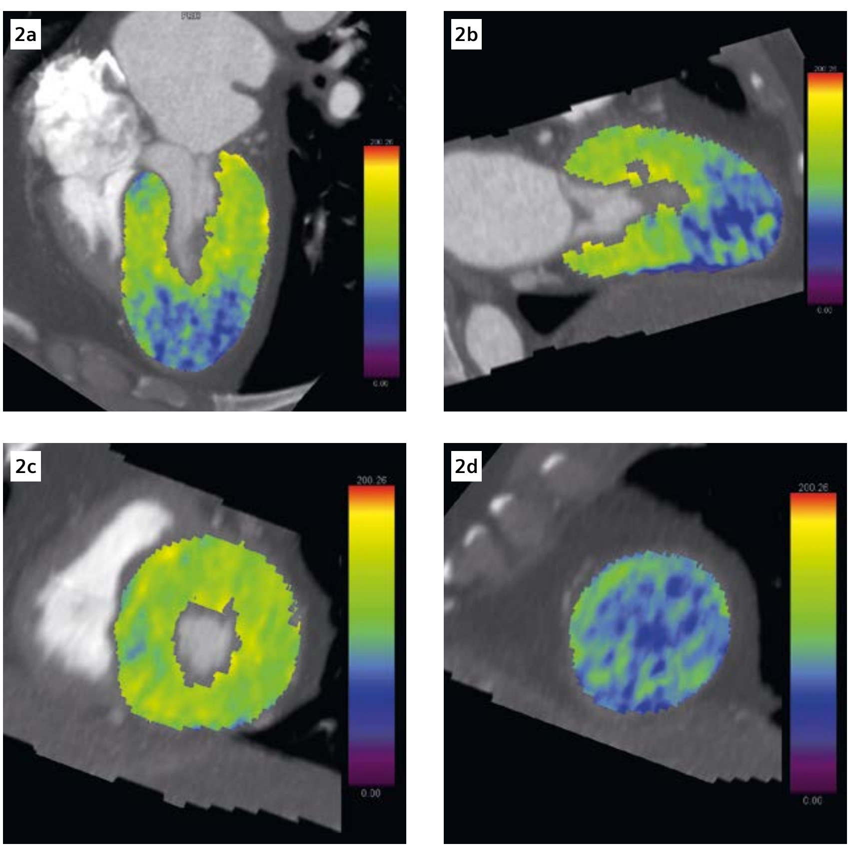




1 Curved MPR images (Fig. 1a, LAD; Fig. 1b, Cx) and a thin MIP image (Fig. 1c) of the coronary CTA show no significant stenoses.

2 Long (Figs. 2a, 2b) and short (Figs. 2c, 2d) axis views of the left ventricle show an extensive MBF reduction in the apical portion compared to the basal area.

History

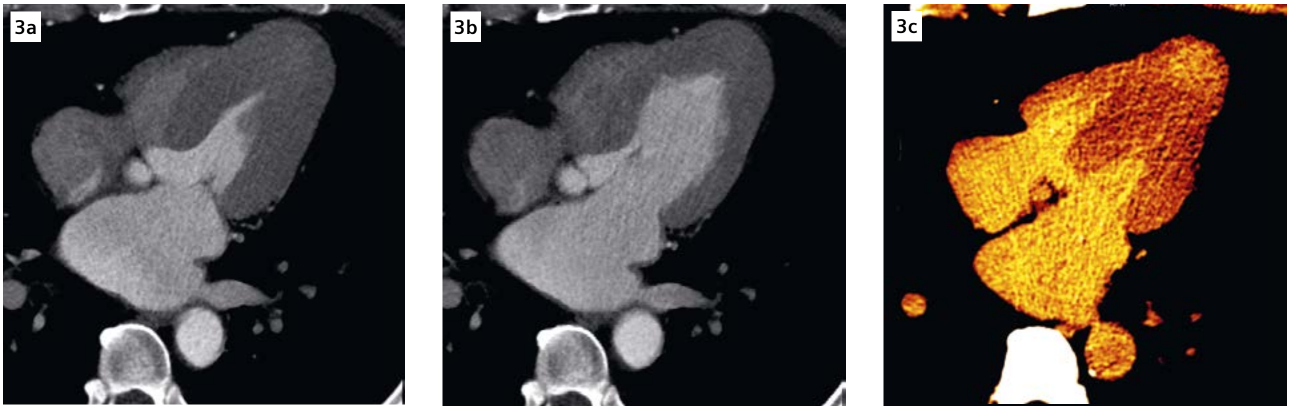
A 61-year-old male patient, complaining of progressive exertional chest tightness, relieved by rest, for the past 11 years, was referred to us with suspected coronary artery disease (CAD). Standard twelve lead electrocardiography (ECG) revealed ST-T segment changes on leads V2-V6 and T wave inversion. A coronary CT angiography (CTA) combined with ATP-stress myocardial CT perfusion was requested to investigate the coronary artery status and myocardial blood flow.

Diagnosis

Coronary CTA images showed mild stenoses in the left anterior descending artery (LAD), the left circumflex (LCX) and the right coronary artery (RCA), all caused by mixed plaques. The long-axis views of the left ventricle, in both systole and diastole, revealed a significantly thickened apical myocardium. Myocardial perfusion images showed an extensive reduction of myocardial blood flow (MBF) in the apical portion. No isolated perfusion defect was demonstrated. In the delayed scans, partial enhancement in the apical myocardium was shown, suggesting local fibrosis.

Comments

Hypertrophic cardiomyopathy (HCM) is characterized by left ventricular (LV) hypertrophy with various phenotypes, of which apical HCM accounts for approximately 2–15%.[1, 2] Clinically, patients with apical HCM may present with exertional angina or dyspnea and may have electrocardiographic findings similar to those with



3 **Long axis views in the systole (Fig. 3a) and diastole (Fig. 3b) show a thickened apical myocardium, partially enhanced in the delayed phase (Fig. 3c), suggesting local fibrosis.**

CAD or in acute coronary syndromes.[1, 3] Some of these patients may be admitted for ICA due to suspected CAD. Therefore, a pre-interventional differential diagnosis is important. Cardiac MR imaging has its advantages,[1, 4, 5] is however limited to its availability and by contraindications. A coronary CTA combined with ATP-stress myocardial CT perfusion can be performed to investigate the coronary arteries, the myocardium thickness and the MBF. In this case, mild coronary stenoses with unmatched extensive reduction of MBF in the significantly thickened apical portion are revealed. This is highly suggestive of an apical HCM.[1–3] These results assist the physicians in making a prompt diagnosis and appropriate treatment planning, as well as to assess the patient's prognosis. ●

References

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Examination Protocol

Scanner	SOMATOM Force		
Scan area	Heart	Heart	Heart
Scan mode	ECG Triggered Sequential scan	Stress Myocardial Perfusion	Dynamic 4D Spiral
Scan length	107 mm	105 mm	105 mm
Scan direction	Cranio-caudal	Shuttle	Shuttle
Scan time	3.8 s	34 s	6 s
Tube voltage	90 kV	70 kV	80 kV
Effective mAs	398 mAs/rot.	275 mAs/rot.	307 mAs/rot.
$CTDI_{vol}$	20.2 mGy	39.73 mGy	24.17 mGy
DLP	218.1 mGy*cm	419.59 mGy*cm	255.2 mGy*cm
Rotation time	0.25 s	0.25 s	0.25 s
Slice collimation	144 × 0.6 mm	192 × 0.6 mm	192 × 0.6 mm
Slice width	0.75 mm	1.5 mm	1.0 mm
Reconstruction increment	0.5 mm	0.7 mm	1.0 mm
Reconstruction kernel	Bv40 (ADMIRE 3)	Qr36	Qr36
Heart rate	74 – 85 bpm	72 – 85 bpm	78 – 83 bpm
Contrast	370 mg/mL	370 mg/mL	–
Volume	45 mL + 45 mL saline	44 mL + 44 mL saline	–
Flow rate	5.0 mL/s	5.5 mL/s	–
Start delay	Bolus tracking at the ascending aorta with 100 HU + 5s	5 s	7 minutes after CTA

Coronary artery fistula and coronary aneurysm – a rare incidental coincidence

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History

A 58-year-old male patient, complaining of recurrent paroxysmal thoracalgia for the past year, presented himself for a check-up. After resting, his symptoms were less pronounced. Physical examinations, electrocardiogram and chest radiograph were unremarkable. A coronary CT angiography (cCTA) was requested for further evaluation.

Diagnosis

cCTA images revealed an anomalous fistula, connecting the proximal left anterior descending artery (LAD) to the main pulmonary artery (MPA). The fistula was tortuous and dilated towards the MPA which inserted directly above the valve on the left side. A saccular aneurysm, measuring 4.6 × 2.5 mm in size, was also shown in the mid segment of the 2nd diagonal branch of the LAD. The origins and the courses of the right coronary artery (RCA), the LAD and the circumflex (Cx) were normal.

Comments

A coronary artery fistula (CAF) is classified as an abnormality in the termination of a coronary artery and defined as an anomalous connection between a coronary artery and a major vessel or cardiac chamber.[1] A coronary artery aneurysm (CAA) is described as a localized dilatation of a coronary artery segment more than 1.5-fold compared with adjacent normal segments.[2] Both CAF and CAA are rare and usually asymptomatic. Nonetheless, these can have fatal outcomes for the patients.

Conventional coronary angiography can reliably demonstrate the proximal part of the CAF. However, the drainage site may not be well seen due to significant dilution of the contrast agent.[1] As the angiography is limited to a "luminogram", it cannot provide adequate information concerning the vessel wall. This could lead to an underestimation of the actual size of an aneurysm or perhaps even to overlook a CAA which may be occluded by a large thrombus or a plaque.[2] Contrary to the invasive approach of the conventional coronary angiography, cCTA is a noninvasive alternative. Potential applications of cCTA include identification of anomalous origin and course of coronary arteries, assessment of the complexity of the fistula, evaluation for aneurysmal dilatation or thrombus formation in the vessel.[2,3]

Excellent three dimensional image data can be acquired by synchronizing image acquisition with cardiac cycle using ECG – either triggered prospectively or gated retrospectively. In each cardiac cycle, the least movement of the coronary arteries is observed in two phases – the end-systole (ES) and the end-diastole (ED). At lower heart rates, the ES phase (approximately 100–150 ms) is much shorter than the ED phase. However as the heart rate increases, the ED phase shortens and can be even shorter than the ES phase while the ES phase remains mostly unchanged.[4]

For comparable signal-to-noise ratio, an ECG-gated spiral acquisition requires a higher patient radiation dose than an ECG-triggered sequential acquisition. This is due to the fact that the ECG-gated acquisition acquires image data with a small spiral pitch and continuous X-ray exposure. Thus patients with a higher and regular heart rate, such as in this case (92 bpm), would benefit from the ECG-triggered sequential scanning in the ES phase – if an appropriate temporal resolution is provided. We performed the cCTA with SOMATOM Force, which provides 66 ms temporal resolution enabling motion-free image acquisition. Additionally, the radiation exposure could be substantially reduced by applying techniques such as CARE Dose4D (automatically controlled tube current modulation) and ADMIRE (advanced modeled iterative reconstruction). The 70 kV setting was chosen automatically by CARE kV (automatic tube voltage optimization), which significantly improved contrast enhancement, although only 35 mL contrast agent was administrated. The lower kV setting also contributes to the radiation dose reduction. ●

Examination Protocol

Scanner	SOMATOM Force
Scan area	Heart
Scan mode	Prospective ECG-triggered sequential scan
Scan length	133 mm
Scan direction	Cranio-caudal
Scan time	4 s
Tube voltage	70 kV
Effective mAs	389 mAs / rot.
Dose modulation	CARE Dose4D
$CTDI_{vol}$	7.84 mGy
DLP	105.9 mGy*cm
Effective dose	1.48 mSv
Rotation time	0.25 s
Slice collimation	192 × 0.6 mm
Slice width	0.75 mm
Reconstruction increment	0.5 mm
Reconstruction kernel	Bv36 / Bv40 (ADMIRE 3)
Heart rate	92 bpm
Contrast	370 mg/mL
Volume	35 mL + 30 mL saline
Flow rate	4 mL/s
Start delay	Bolus tracking + 5 s

References

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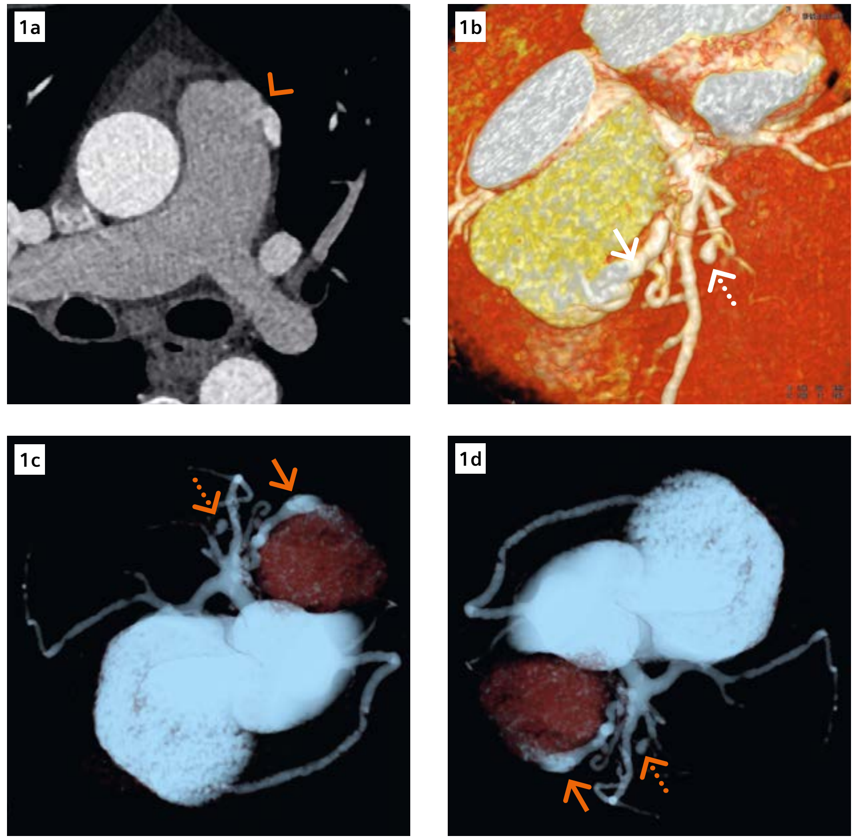

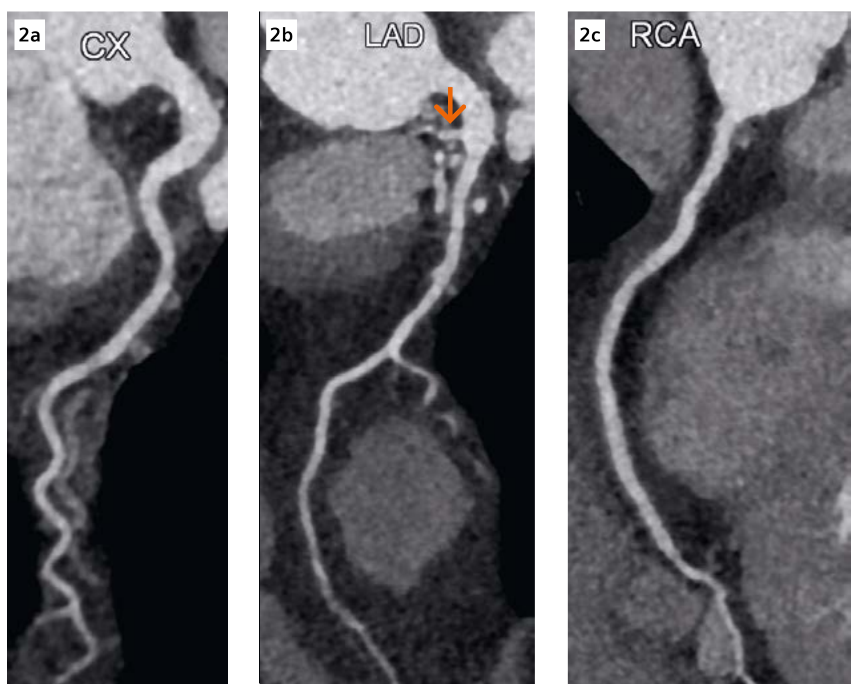

1 An axial image (Fig. 1a) shows the insertion of the fistula (arrowhead) into the MPA on the left side. VRT images (Figs. 1b–1d) reveal a tortuous fistula (arrows) connecting the proximal LAD to the MPA, and a small aneurysm (dashed arrows) in the mid segment of the 2nd diagonal branch of the LAD.

2 Curved MPR images show normal origins and courses of the RCA, the LAD and the Cx. The fistula coming off the proximal LAD (arrow) is also shown.

Coronary stenoses caused by extensive calcification – hemodynamic relevance?

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History

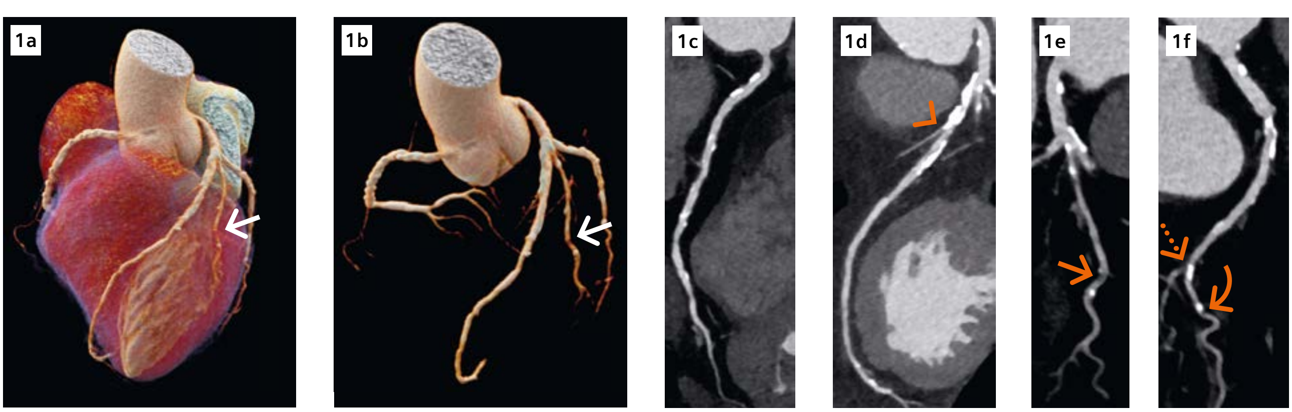
A 70-year-old female patient, suffering from chest pain with both typical and atypical elements, presented herself to the hospital. The patient had an intermediate coronary risk profile and a history of coronary stenosis (70% in ramus intermedius) revealed in a conventional coronary angiography from 2010. A stress-ECG test was inconclusive. A comprehensive cardiac CT study, including Coronary CT angiography (CTA) and Stress Myocardial Dynamic Perfusion, was ordered to simultaneously evaluate both the coronary arteries and the myocardium.

Diagnosis

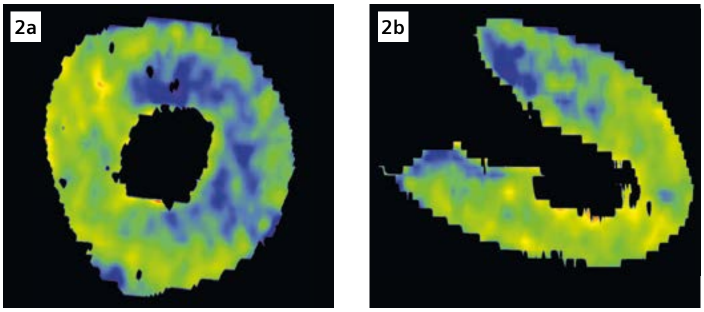
Coronary CTA images showed a right coronary artery (RCA) dominant system. Extensive calcified plaques were seen in all coronary arteries, and in part severe, obscuring the luminal views. A calcium score of 1333 was calculated. The origin of the first diagonal and marginal branch, the mid segment of the RI and the distal circumflex (LCX) were severely stenosed.
Adenosine-induced Stress Myocardial Dynamic Perfusion CT images showed an overall moderate reduction of the myocardial perfusion, slightly pronounced circumferentially in the basal area. MBF values, measured in the polarmap, revealed hemodynamic relevance in the basal segments 1, 4, 5 and 6. No isolated perfusion defect was demonstrated. Since the reduced stress perfusion suggested triple vessel disease, X-ray coronary angiography was performed. CT findings were confirmed with over 70% of the stenoses.

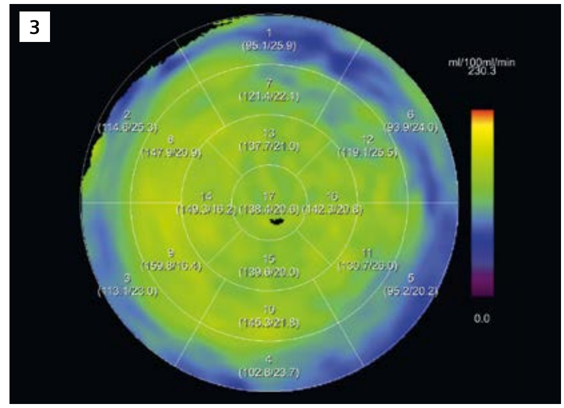
Comments

In case of an extensive calcification of the coronary arteries, it is difficult to evaluate the stenoses. However, the myocardial perfusion and viability can be assessed regardless of the conditions of the coronary arteries. A quantitative myocardial stress perfusion CT is performed using adenosine-mediated vasodilation and dynamic CT scan with contrast agent. Time-resolved attenuation curves are reconstructed as the contrast agent passes through the heart and perfusion parameters, such as myocardial blood flow (MBF), are calculated using a deconvolution algorithm. In this case, a systolic ECG-triggered Sequential Shuttle mode is applied with an absolute delay of 250 ms. Systolic acquisition with an absolute delay is insensitive to extrasystolic events and it improves myocardial perfusion



1 VRT images (Figs. 1a, 1b) and curved MPR images (Figs. 1c–f) show extensive calcified plaques in all coronary arteries. Severe stenoses are visualized in the mid segment of the RI (Figs. 1a, 1b, 1e; arrows), the distal LCX (curved arrow), the first diagonal (Fig. 1d; arrowhead) and marginal branch (Fig. 1f; dotted arrow). No significant stenosis is seen in the RCA (Fig. 1c).





2 MBF images in both short (Fig. 2a) and long (Fig. 2b) axis reveal reduced basal blood flow, corresponding to hypoperfusion.

3 MBF of the endocardial compartment in AHA polarmap display. Basal Segments 1, 4, 5 and 6 have MBF values between 94 and 103 mL/100 mL/min, corresponding to a range of 67 to 72% of the remote myocardium (defined by the 75% percentile of all segments). Both ranges are below the respective cutoff values (106 mL/100 mL/min and 73%) for hemodynamic relevance determined in a recent study [1] that used invasive FFR as reference.

evaluation since the myocardium is thicker in systole. Additionally, techniques associated with radiation dose reduction, such as CARE Dose4D (Real time Anatomic Exposure Control) and CARE kV (Automatic Tube Voltage Optimization) were applied, to achieve excellent image quality with limited radiation exposure. A software application for cardiac perfusion evaluation enables a fast calculation of the myocardial blood flow and allows a polarmap display providing segmental values. Respective cutoff values for hemodynamic relevance have been published in a recent study that used invasive FFR as reference.[1] ●

References

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Examination Protocol

Scanner	SOMATOM Force		
Scan area	Heart	Heart	Heart
Scan mode	Turbo Flash Calcium Score	Turbo Flash CTA	Dynamic CT Perfusion
Scan length	130.5 mm	131.4 mm	102 mm
Scan direction	Cranio-caudal	Cranio-caudal	Shuttle
Scan time	0.18 s	0.18 s	30 s
Tube voltage	120 / 120 kV	90 / 90 kV	70 kV
Effective mAs	88 mAs	444 mAs	169 mAs
Dose modulation	CARE Dose4D	CARE Dose4D	CARE Dose4D
$CTDI_{vol}$	1.49 mGy	3.14 mGy	24.48 mGy
DLP	25.7 mGy*cm	54 mGy*cm	258.5 mGy*cm
Rotation time	0.25 s	0.25 s	0.25 s
Pitch	3.2	3.2	NA
Slice collimation	192 × 0.6 mm	192 × 0.6 mm	48 × 1.2 mm
Slice width	3 mm	0.6 mm	3 mm
Reconstruction increment	1.5 mm	0.3 mm	2 mm
Reconstruction kernel	Qr36	Bv40 (ADMIRE 3)	Qr36
Heart rate	70 bpm	66 bpm	90 bpm
Contrast	–	350 mg/mL	350 mg/mL
Volume	–	68 mL + 50 mL saline	50 mL + 50 mL saline
Flow rate	–	4 mL/s	6 mL/s
Start delay	–	11 s	10 s

Revealing a myocardial perfusion defect, unseen on MRI, using adenosine-stress Dual Energy CT

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History

A 68-year-old male patient, with a known history of coronary artery disease, was referred to our hospital due to unclear chest pain. Previously the patient had undergone percutaneous coronary angioplasty with stent placement. An adenosine-stress myocardial perfusion MRI was performed revealing no perfusion defect. Thereafter, the patient was referred for a coronary CT angiography with adenosine-stress myocardial perfusion using Dual Energy CT (DECT) mode.

Diagnosis

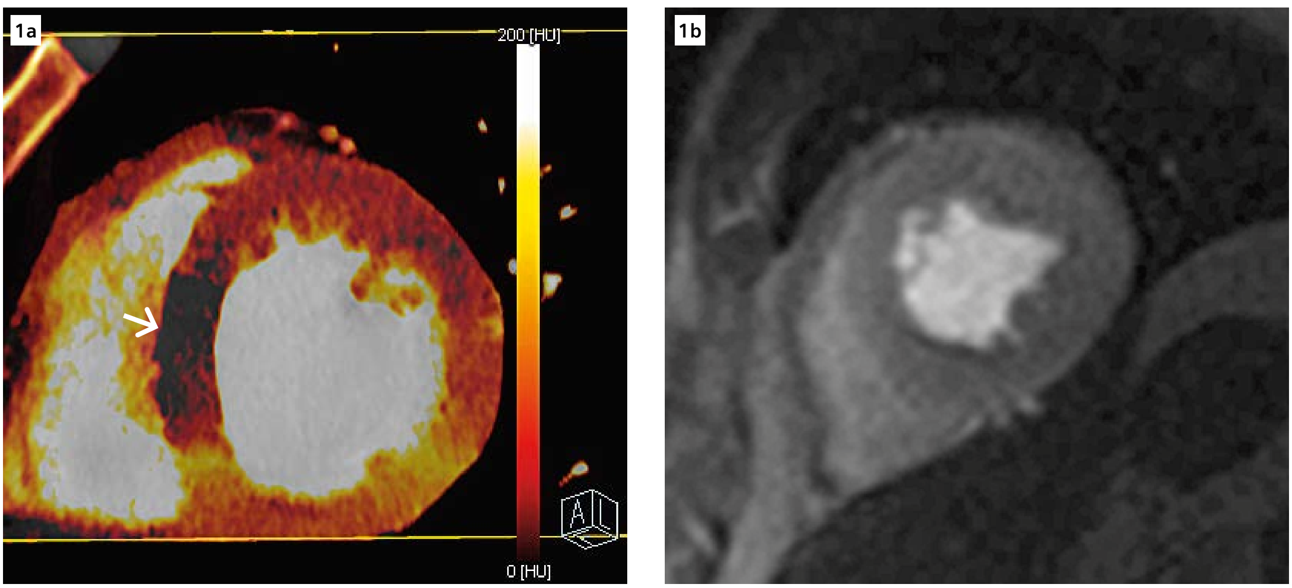
CT was carried out directly under stress conditions after an i.v. infusion of adenosine (140 µg per kg body weight per minute) and no rest phase. CT angiography with systolic reconstruction revealed a moderate stenosis in the mid-left anterior descending coronary artery (LAD) caused by a non-calcified plaque. Myocardial iodine distribution maps, as a surrogate for myocardial perfusion generated using *syngo*.CT DE Heart PBV, showed a large perfusion defect in the mid-septum with normal wall motion and no late enhancement (not shown). Invasive coronary angiography confirmed the LAD stenosis with a pathological fractional flow reserve (FFR) of 0.68 and was therefore stented. An additional high-grade septal branch stenosis was seen but not treated due to its small vessel caliber.

Comments

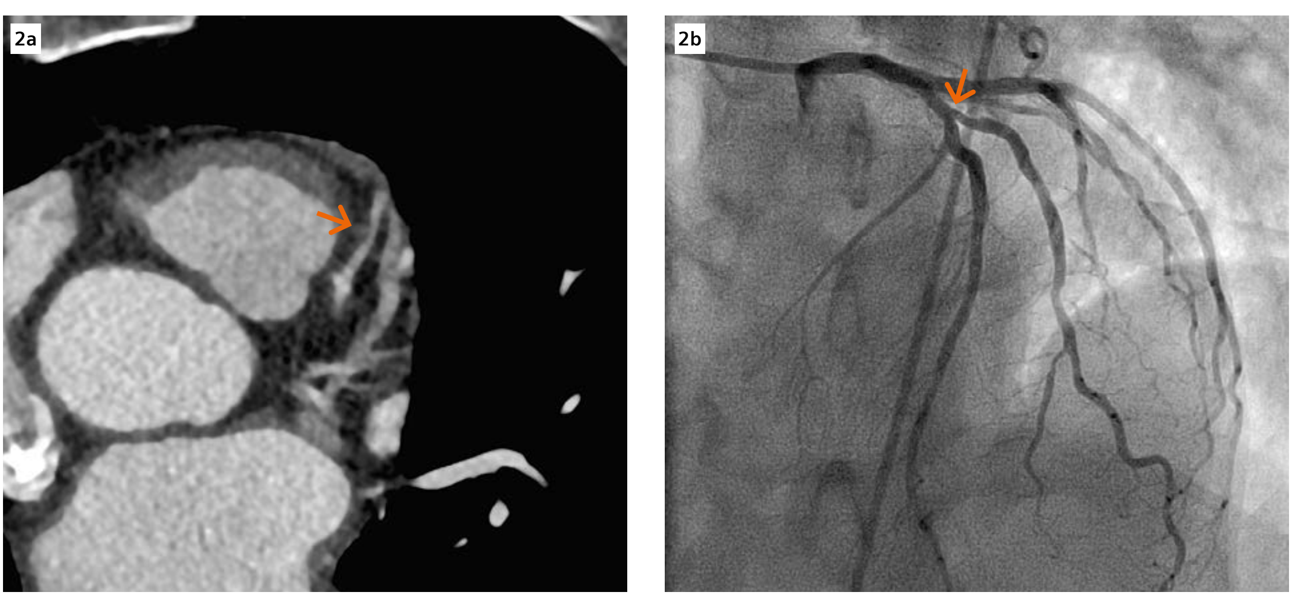
The contradicting results of two "gold standard" tests, i.e. adenosine-stress MRI and invasive FFR, makes this case interesting. While MRI, as the preferred non-invasive imaging test in this clinical scenario, is negative whereas a still novel and non established method, i.e. adenosine-stress DECT, delivers both information on a moderate LAD stenosis and its impact on myocardial perfusion with an obvious perfusion defect of the septum in agreement with invasive coronary angiography and FFR measurement. This case highlights the necessity of deepening research and widening clinical implication of myocardial perfusion imaging with DECT as it can provide both morphological and functional information from one scan. Compared to time-resolved myocardial imaging approaches, such as dynamic perfusion CT or MRI, DECT images are acquired in just one single breath-hold within typically 8–10 seconds shortly after peak aortic enhancement. In our opinion, this makes the Dual Energy approach to myocardial perfusion imaging an attractive method with enormous potential for clinical use. ●

Examination Protocol

Scanner	SOMATOM Force
Scan area	Heart
Scan mode	Dual Source Dual Energy
Scan length	97 mm
Scan direction	Cranio-caudal
Scan time	2.3 s
Tube voltage	90 / Sn150 kV
Effective mAs	130 / 102 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	20.75 mGy
DLP	266.3 mGy*cm
Effective dose	3.7 mSv
Rotation time	0.25 s
Pitch	0.28
Slice collimation	128 × 0.6 mm
Slice width	1.5 mm
Reconstruction increment	1.0 mm
Reconstruction kernel	Qr40 ADMIRE 2
Heart rate	68 – 83 bpm
Contrast	400 mg/mL
Volume	50 mL
Flow rate	5 mL/s
Start delay	Test bolus



1 Mid-ventricular short axis view of iodine distribution maps of stress DECT (Fig. 1a, arrow) reveals a large septal perfusion defect which is not seen in the stress myocardial perfusion MRI (Fig. 1b).



2 CT angiography with systolic reconstruction shows a moderate stenosis of the LAD (Fig. 2a, arrow). An invasive coronary angiography (Fig. 2b, arrow) confirms CTA results with pathological FFR of the LAD stenosis of 0.68 indicating an ischemia.

Ultra-fast low-dose coronary CTA at 0.37 mSv and with 35 mL contrast agent

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History

A 77-year-old male patient, with multiple risk factors including hypertension, hyperlipidemia, and history of cigarette smoking, was admitted with recent onset of chest discomfort and shortness of breath at rest. The physical examination was unremarkable. Patient characteristics, including body mass index (25 kg/m^2), blood pressure (130/80 mmHg) as well as ECG and echocardiography, were normal at admission. The chest discomfort and shortness of breath persisted after admission and an initial set of cardiac troponin I showed a level of 0.04 ng/mL. The patient was subsequently referred for coronary CT angiography (cCTA) for further evaluation.

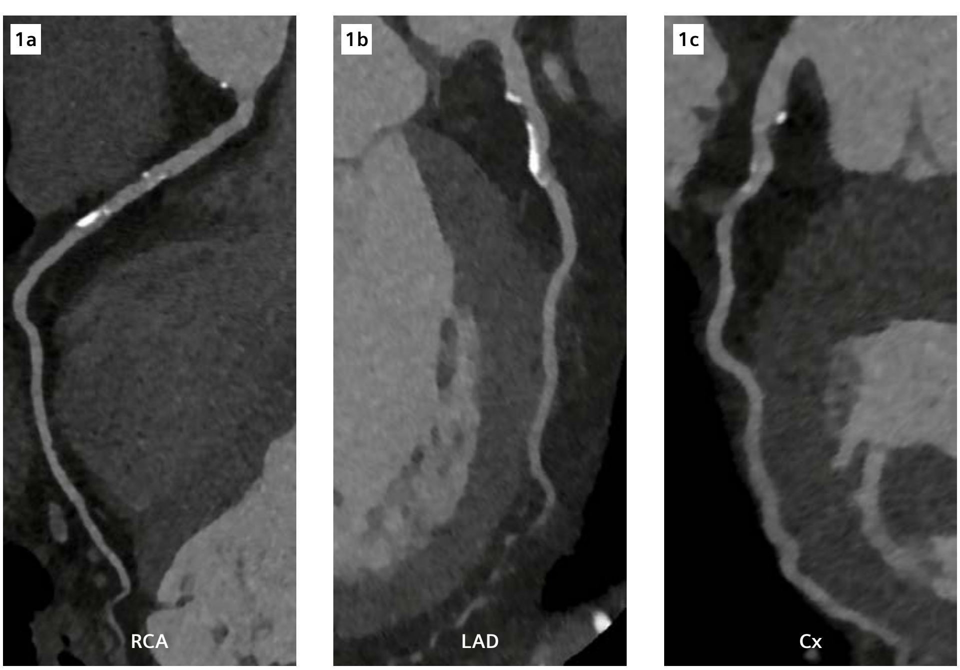
Diagnosis

Calcium scoring revealed multiple calcifications in the left main (LM), left anterior descending (LAD), right (RCA) and circumflex (Cx) coronary arteries, most distinct in the LAD. The total calcium score was 509, corresponding to the 61st age, race, and gender adjusted percentile. cCTA images demonstrated an approximately 50% stenosis of the mid LAD segment and mid CX without LM stenosis. An extensive calcified plaque caused significant stenosis (>50%) of the ostium of the first diagonal branch off the LAD. The RCA showed only mild luminal irregularities in the mid-vessel segment.

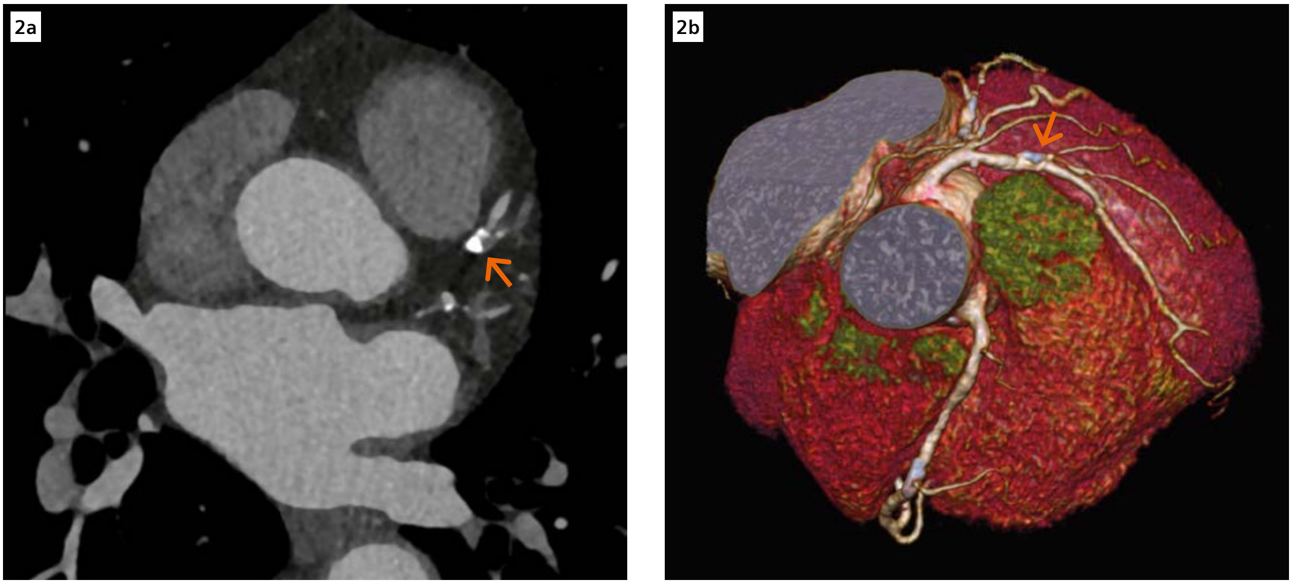
Invasive cardiac catheterization was performed, confirming the stenosis (>70%) of the first diagonal branch. An everolimus-eluting stent was successfully deployed after balloon angioplasty. An excellent angiographic result was achieved. The patient was safely discharged 24 hours after the procedure without recurrence of symptoms during follow-up.

Comments

In this case, cCTA helped obtain a definitive diagnosis and aided immediate treatment in a patient with atypical chest pain and a medium risk for coronary artery disease. Excellent



1 **Curved MPR images show mild stenosis in the LAD and the Cx, as well as luminal irregularities in the RCA.**



2 **Axial (Fig. 2a) and VRT (Fig. 2b) images reveal extensive calcified plaque in the proximal LAD which causes a severe stenosis at the ostium of the first diagonal branch (arrows). Multiple calcified plaques are shown in all 3 coronary arteries (Fig. 2b).**

image quality, despite diffuse coronary calcifications, allowed for the detection of hemodynamic-relevant stenosis and facilitated planning of the percutaneous interventional procedure. Timely diagnosis is a decisive factor in the management of unstable angina considering that "time is myocardium".
All available latest Dual Source CT radiation dose-saving techniques were applied in this case. ECG-gated ultra-high-pitch acquisition was performed, automated tube current modulation (CARE Dose4D) was activated, and automated tube voltage modulation (CARE kV) resulted in a 70 kV image acquisition. The estimated effective dose was only 0.37 mSv. Performing the scan at 70 kV allowed restricting the contrast media bolus to only 35 mL due to the increased intravascular attenuation of iodine. To further decrease image noise associated with the low tube voltage, advanced image-based iterative reconstruction (ADMIRE, level 3, 4, 5) was performed. ●

Examination Protocol

Scanner	**SOMATOM Force**
Scan area	Heart
Scan mode	Turbo Flash mode
Scan length	125.7 mm
Scan direction	Cranio-caudal
Scan time	0.17 s
Tube voltage	70 kV (CARE kV)
Effective mAs	555 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	1.56 mGy
DLP	26.1 mGy*cm
Effective dose	0.37 mSv
Rotation time	0.25 s
Pitch	3.2
Slice collimation	192 × 0.6 mm
Slice width	0.5 mm
Reconstruction increment	0.3 mm
Reconstruction kernel	Bv40 (ADMIRE)
Heart rate	62 bpm
Contrast	370 mg/mL
Volume	35 mL + 50 mL saline
Flow rate	2.2 mL/s
Start delay	Bolus tracking + 4 s

Diagnosis of reversible myocardial ischemia using Dynamic CT Perfusion: confirmation by ^{15}O-labelled water PET/CT

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History

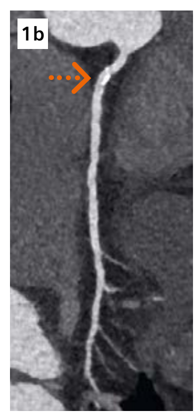
A 72-year-old male patient, suffering from diabetes mellitus and elevated triglyceride levels, was admitted for surgical resection of an adrenal tumor. Echocardiography was performed for preoperative cardiovascular assessment. This revealed a regional hypokinesis in the posterior wall of the left ventricle. A cardiac CT and a ^{15}O-labelled water PET/CT were requested for further evaluation.

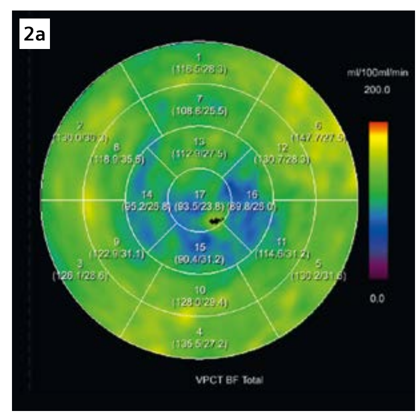
Diagnosis

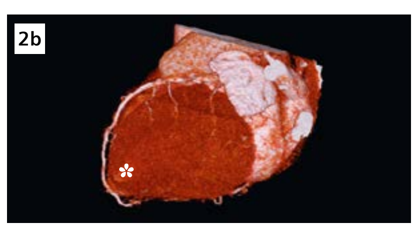
Coronary CT angiography images depicted a high grade stenosis caused by non-calcified plaques in the proximal left anterior descending artery (LAD, Fig. 1a), and a mild stenosis caused by calcified plaques in the proximal right coronary artery (RCA, Fig. 1b). The circumflex artery (Cx) was hypoplastic, and no plaques were seen in the left-main coronary artery (LM).

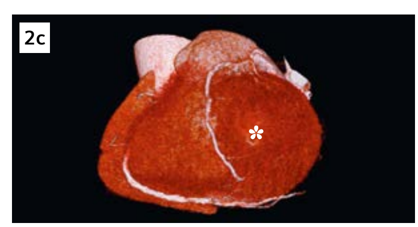
Myocardial blood flow maps, derived from dynamic CT perfusion, revealed a significant reduction of blood flow in the area subtended to the LAD (Figs. 2a and 3a).

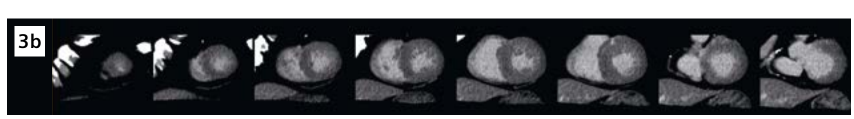
Delayed enhancement CT showed no abnormal enhancement and no evidence of infarction in the area with reduced perfusion (Fig. 3b).









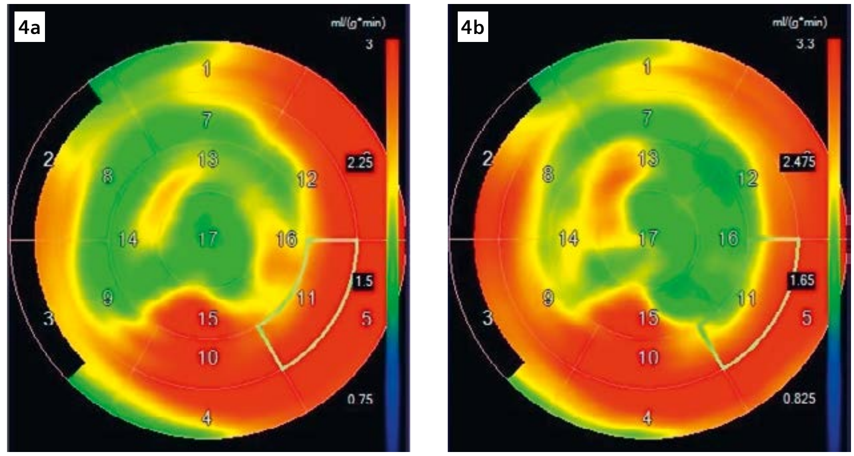


1 Curved MPR images of the LAD (Fig. 1a) and the RCA (Fig. 1b) show a high-grade stenosis in the proximal LAD (Fig. 1a, arrow) and a mild stenosis in the proximal RCA (Fig. 1b, dashed arrow).

2 A polar map of myocardial blood flow derived from dynamic CT perfusion shows reduced perfusion in the anterior and apical segments (Fig. 2a). Volume rendering images (Figs. 2b and 2c) show LAD wrapping around the apex (asteriks).

3 Short axis images of myocardial blood flow map (Fig. 3a) and delayed enhancement CT (Fig. 3b) show no evidence of infarction in the area with reduced perfusion.

Quantitative polar maps of myocardial perfusion obtained from ^{15}O-labelled water PET/CT also demonstrated reduced myocardial blood flow under stress and myocardial perfusion reserve in the LAD territory (Fig. 4).



4 **Polar maps of myocardial blood flow (Fig. 4a) and myocardial perfusion reserve (Fig. 4b) obtained from ^{15}O-labelled water PET/CT demonstrate reduced perfusion in the anterior and apical segments showing good agreement with the CT-derived polar map (Fig. 2a).**

Comments

Cardiac CT has evolved from the morphological assessment of coronary arteries to the assessment of myocardial perfusion and viability. As exemplified above, a comprehensive cardiac CT examination can provide almost all needed information to guide patient management and develop therapeutic strategies. Dynamic CT perfusion, which had been limited by relatively high radiation and insufficient z-axis coverage, has broadened its clinical applicability since the introduction of SOMATOM Force. This new system allows higher tube current at lower tube voltage and has a 96-row detector covering 10.5 cm in the cardiac shuttle mode.

^{15}O-labelled water PET/CT imaging is considered the gold standard for the quantitative assessment of myocardial perfusion because ^{15}O-labelled water is a freely diffusible agent and the extraction fraction is not affected by flow rates or the metabolic state of the myocardium. However, despite promising results in the research context, its availability is extremely limited. As shown here, dynamic CT perfusion can provide quantitative parametric maps that agree well with ^{15}O-labelled water PET/CT. ●

Examination Protocol

Scanner	SOMATOM Force		
Scan area	Left ventricle	Heart	Left ventricle
Scan mode	Stress myocardial perfusion	cCTA (Seq.)	Delayed enhancement CT
Scan length	105 mm	120 mm	105 mm
Scan direction	Shuttle	Cranio-caudal	Shuttle
Scan time	32 s	5 s	8 s
Tube voltage	70 kV	80 kV	80 kV
Effective mAs	182 mAs/rot.	247 mAs/rot.	278 mAs/rot.
Dose modulation	CARE Dose4D	CARE Dose4D	CARE Dose4D
$CTDI_{vol}$	24.2 mGy	10.4 mGy	15.8 mGy
DLP	255.8 mGy*cm	128.1 mGy*cm	167.2 mGy*cm
Effective dose	3.6 mSv	1.8 mSv	2.3 mSv
Contrast	370 mg/mL	370 mg/mL	–
Volume	40 mL	60 mL	–
Flow rate	5 mL/s	4.7 mL/s	–
Start delay	4 s	Bolus tracking	–
Scan timing	Adenosine infusion start ↓ 3 min scan	Adenosine infusion release ↓ Nitro ↓ 5 min scan	cCTA ↓ 7 min scan

Combined coronary and carotid CTA with 60 mL contrast agent and a radiation dose of only 1.7 mSv

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History

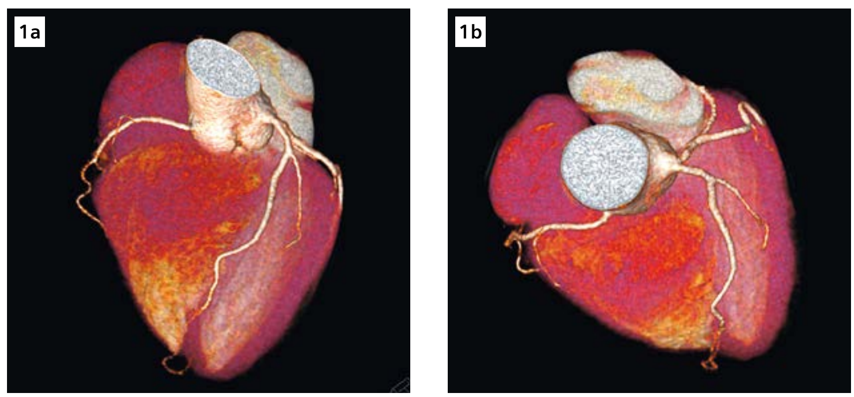
A 55-year-old male patient, with atypical chest pain, syncope, hyperlipidemia, and a family history of coronary artery disease (CAD), underwent a treadmill test. This was inconclusive due to a left-bundle branch block. A coronary and a carotid CT angiography (CTA) were requested by the referring physician to rule out coronary and/ or carotid artery disease.

Diagnosis

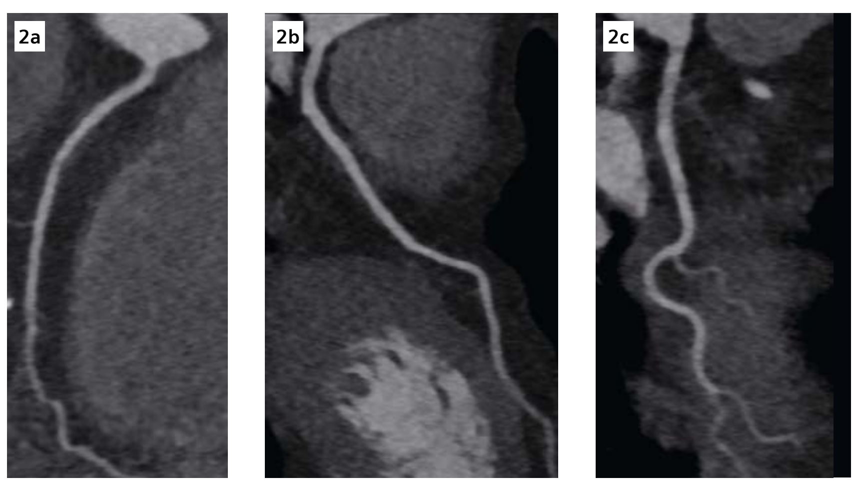
The coronary CTA (cCTA) showed no evidence of coronary plaques or stenoses. A small calcification area in the pericardium, next to the right atrium posterior wall, was seen. There were also no clinical findings in the carotid CTA.

Comments

cCTA and carotid CTA are valuable, noninvasive imaging examinations that support the physician in diagnostic accuracy. Previously, with a single source CT scanner, two separate acquisitions had to be performed resulting in a higher radiation dose and the need for contrast agent of 70 mL for cCTA and 50 mL for carotid CTA. Using a Dual Source CT scanner (SOMATOM Definition Flash), both acquisitions are combined into one, necessitating only 60 mL contrast agent. This is made possible by performing a spiral scan in Flash mode with a very high pitch of 3.4. Radiation dose is also reduced due to advanced technologies such as a Stellar detector and sinogram affirmed iterative reconstruction (SAFIRE). A slice width of 0.5 mm also improves the definition of the vessel lumen and reduces blooming of the stent material. ●



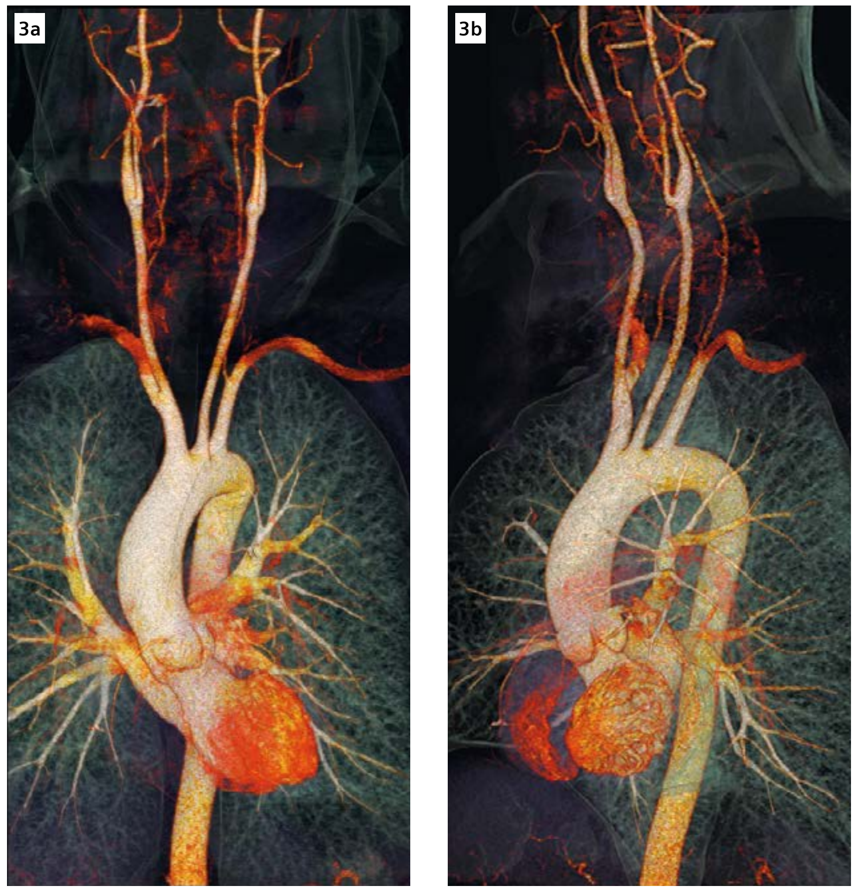
1 VRT images from the cCTA show no evidence of coronary plaques or stenosis.



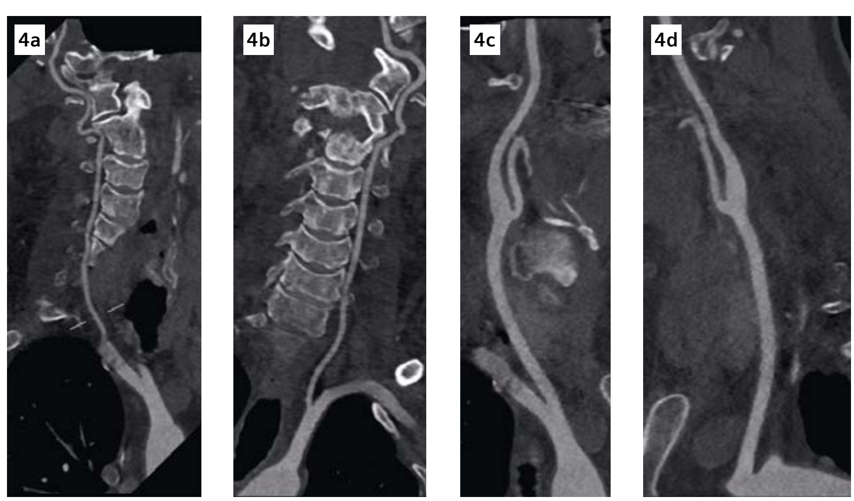
2 Curved MPR images of the RCA (Fig. 2a), the LAD (Fig. 2b) and the Cx (Fig. 2c) show no evidence of coronary plaques or stenosis.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Neck/Thorax
Scan mode	Flash mode
Scan length	416.5 mm
Scan direction	Caudo-cranial
Scan time	0.91 s
Tube voltage	100 kV
Effective mAs	282 mAs /rot.
Dose modulation	CARE Dose4D
$CTDI_{vol}$	2.75 mGy
DLP	129 mGy*cm
Effective dose	1.73 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 × 0.6 mm
Slice width	0.5 /0.6 /0.75 mm
Reconstruction increment	0.3 /0.4 /0.5 mm
Reconstruction kernel	I26 (SAFIRE)
Temporal resolution	75 ms
Heart rate	60 – 73 bpm
Contrast	350 mg/mL
Volume	60 mL
Flow rate	5 mL/s
Start delay	Test bolus + 5 s



3 **VRT images show an overview of the whole scan range.**



4 **Curved MPR images show normal bilateral vertebral and carotid arteries.**

Coronary CTA with 80 kV: improving image quality with reduced radiation and contrast medium dose

Takehito Shizuka, MD[1], Haruka Iwase, MD[1], Hiroaki Kobayashi, MD[1], Yae Matsuo, MD[1], Saburou Yanagisawa, MD[1], Nobuaki Fukuda, MD[1], Akihiro Saitou, MD[1], Shitoshi Hiroi, MD[1], Toyoshi Sasaki, MD[1], Chikashi Negishi, MD[2], Youichi Satou, MD[2]

[1] Department of Cardiology; [2] Diagnostic Imaging Center; National Hospital Organization Takasaki General Medical Center, Japan

History

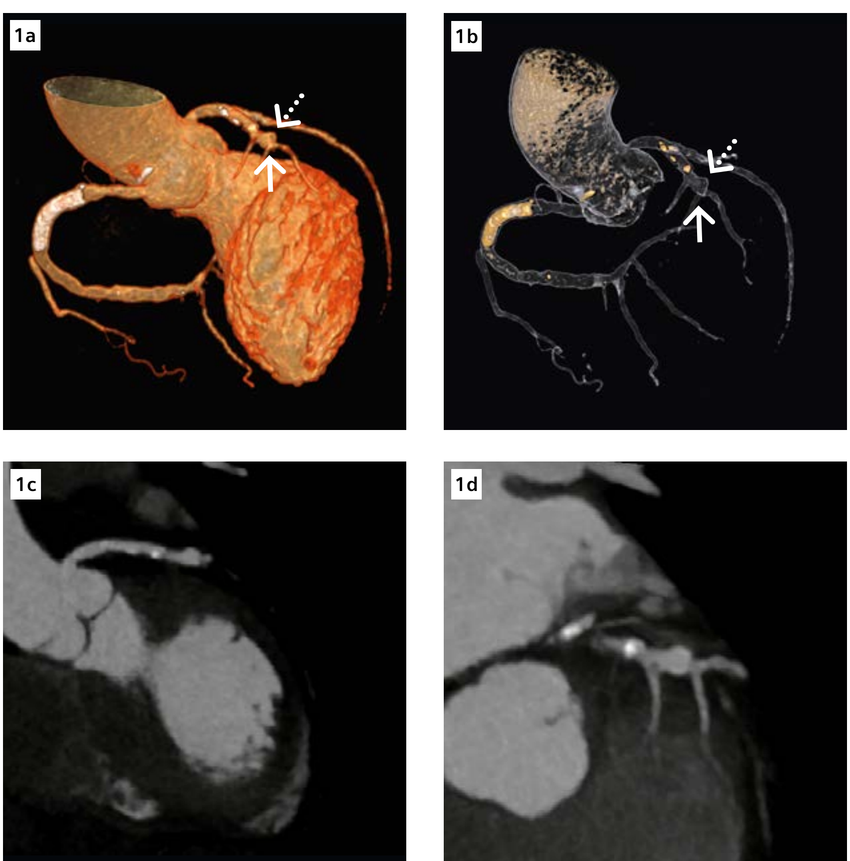
An 84-year-old female patient, with a history of hypertension and dyslipidemia, was hospitalized due to heart failure. Cardiac enzyme tests were normal. After an improvement of her heart failure, the first coronary CTA was performed. This revealed an aneurysm and a chronic total occlusion (CTO) of the left anterior descending artery (LAD) and a 75% stenosis of the right coronary artery (RCA) which was then treated with a stent. A second coronary CTA was performed to evaluate the characteristics of the CTO after the intervention.

Diagnosis

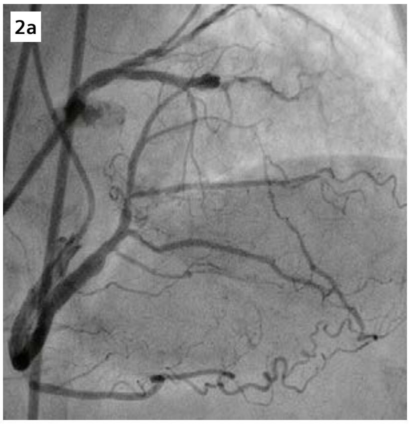
An aneurysm located directly in front of the diagonal and the septal branches, as well as the CTO (Figs. 1a and 1b), could be clearly visualized in the LAD. Neither calcified plaques nor thrombosis were seen in the aneurysm (Figs. 1c and 1d). A stent shown in the proximal RCA was patent (Fig. 3a). The distal branches of the RCA were well developed supposedly to compensate the limited blood supply of the occluded LAD. A few small calcified plaques were present in the proximal circumflex artery (Cx, Fig. 3b).

Comments

To achieve the optimal CT image quality with the lowest possible dose, various CT techniques have been established. In the newly developed Stellar Detector, the photodiode and the analog-to-digital converters (ADCs) were combined in single application-specific integrated circuit (ASICs). This therefore reduces the path of the analog signal and decreases the electronic noise which



1 **VRT images with different presets (Figs.1a and 1b) showed the CTO (arrows) and the aneurysm (dashed arrows) in the LAD. Neither calcified plaques nor thrombosis were seen in the aneurysm (Fig. 1c – MPR and Fig. 1d – MIP).**

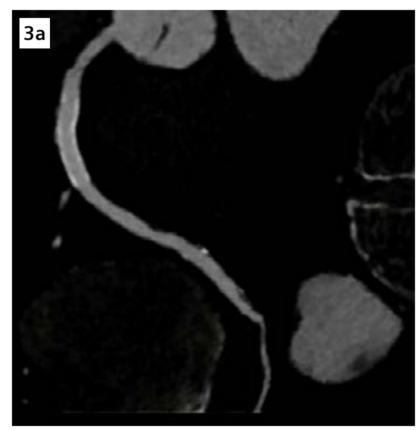


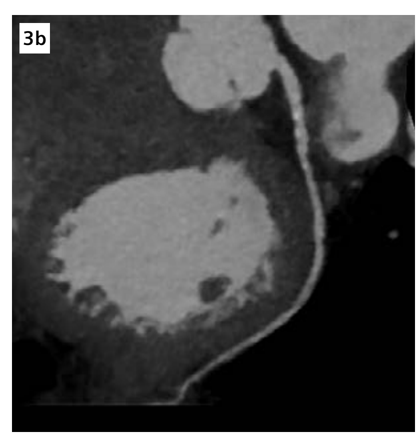
2 **An angiographic image (Fig. 2a) and a VRT image (Fig. 2b) demonstrate both left and right coronary arteries.**

in turn directly enhances the image quality. In this case, SAFIRE as a raw data-based iterative reconstruction technique, Flash Cardio Spiral provided by Dual Source CT, CARE kV, and CARE Dose4D were all additionally applied to minimize the dose to 0.38 mSv while maintaining the image quality. The 80 kV setting selected by CARE kV remarkably enhanced the contrast although only 42 mL (including test bolus injection) contrast medium were used. ●

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Heart
Scan mode	Flash mode
Scan length	111 mm
Scan direction	Cranio-caudal
Scan time	0.2 s
Tube voltage	80 kV with CARE kV
Effective mAs	316 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	1.46 mGy
DLP	27.1 mGy*cm
Effective dose	0.38 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 x 0.6 mm
Slice width	0.75 mm
Reconstruction increment	0.4 mm
Reconstruction kernel	I36f (SAFIRE)
Heart rate	56 bpm
Contrast	
Volume	42 mL (including test bolus)
Flow rate	3.5 mL/s
Start delay	Test Bolus





3 **A patent stent in the RCA (Fig. 3a) and few small calcified plaques could be revealed with curved MPRs (Fig. 3b).**

Unroofed coronary sinus syndrome – diagnosis with Dual Source CT using Flash mode

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[2] Siemens Healthineers, China

History

A 70-year-old female patient with a known history of hypertension presented herself to the hospital complaining of stuffiness in the chest for the past two months. A Dual Source Coronary CT Angiography (CTA) was performed to rule out coronary heart disease.

Diagnosis

The CTA images clearly showed an atrial septal defect (ASD, Figs. 1–3) with left-to-right shunting. The coronary sinus (CS) opened into the left atrium (Figs. 1–4), and the great and middle cardiac veins were enlarged before they joined the coronary sinus. An anomalous vascular structure, running in the right atrio-ventricular groove, along with the right coronary artery connected the right atrium and the coronary sinus (Figs. 1–5). Mixed plaques were present in the proximal left anterior descending (LAD) artery with less than 50% luminal stenosis (Fig. 6). The other coronary vessels appeared to be normal.

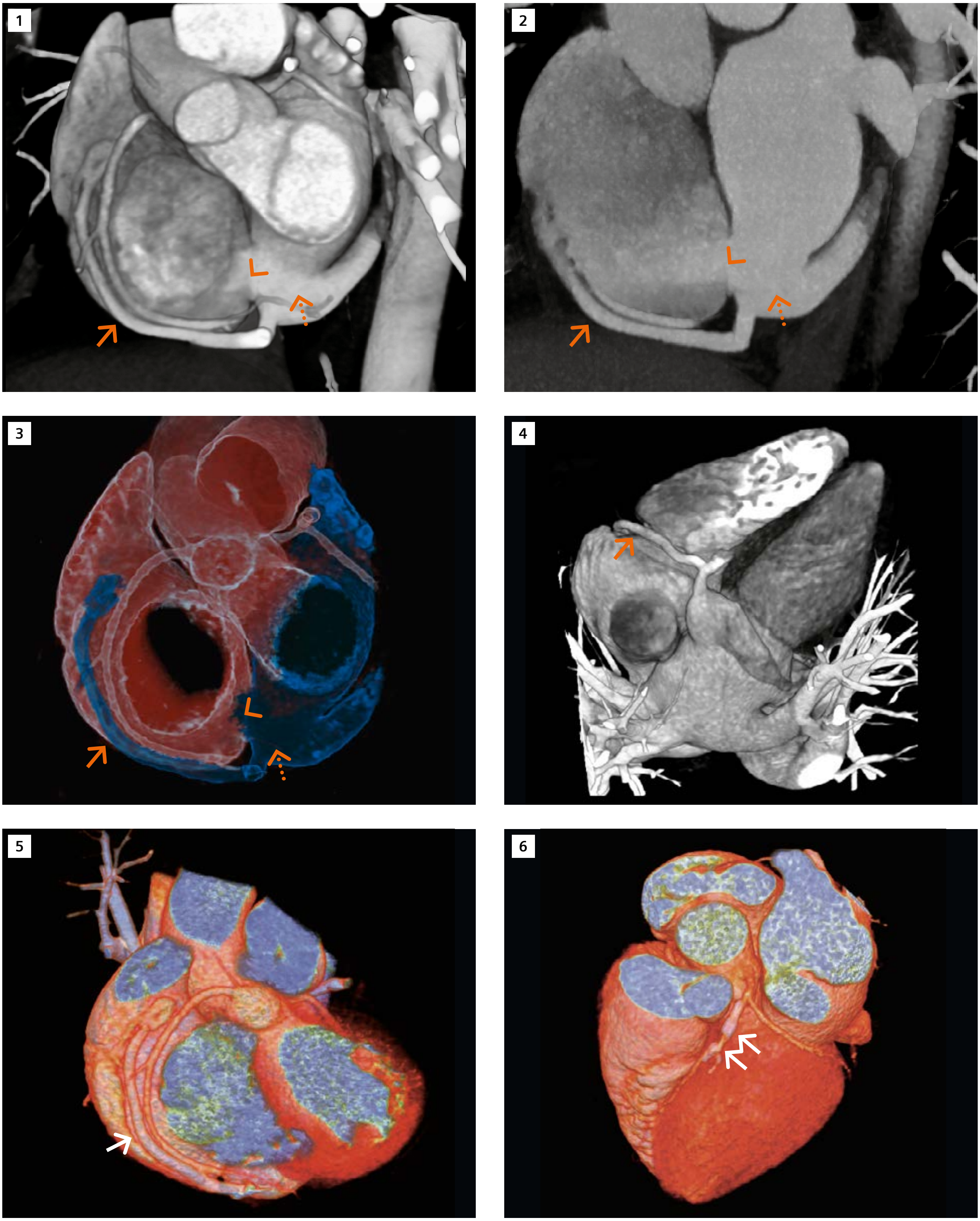
Comments

Unroofed coronary sinus syndrome (URCS), also called coronary sinus septal defect, is a rare congenital cardiac anomaly. The roof of the CS is either partially or completely absent resulting in a communication between the CS and the left atrium (LA). Trans-thoracic echocardiography is the most widely used imaging modality for suspected unroofed CS, but is limited in its ability to visualize the posterior cardiac structures such as the CS. Dual Source CT, with its excellent spatial and temporal resolution, allows for the visualization and the evaluation of the posterior structures of the heart. With its widespread use for coronary artery assessment, Dual Source CT is emerging as a potentially useful non-invasive imaging modality for the evaluation of the coronary venous system. A variety of new techniques can be combined to reduce the radiation dose and to achieve better image quality. In this case, CARE Dose4D, tube voltage of 100 kV and Flash Mode using a pitch of 3.4 were jointly used to lower the patient radiation dose to only 0.94 mSv. ●

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Heart
Scan mode	Flash mode
Scan length	195 mm
Scan direction	Cranio-caudal
Scan time	0.42 s
Tube voltage	100 kV
Effective mAs	266 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	2.6 mGy
DLP	67 mGy*cm
Effective dose	0.94 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 x 0.6 mm
Slice width	0.75 mm
Reconstruction increment	0.4 mm
Reconstruction kernel	B26f
Heart rate	58 bpm

Contrast	
Volume	60 mL
Flow rate	4 mL/s
Start delay	19 s

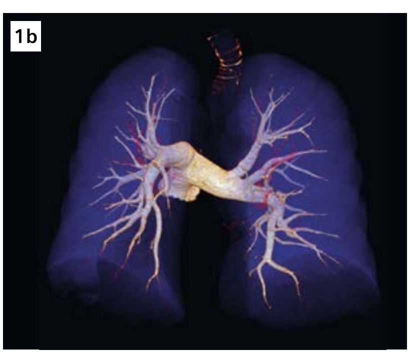


1–6 **The ASD and jet of dense contrast (left-to-right shunt) entering the right atrium (arrowhead), as well as the site of the unroofing (dashed arrows) are shown in Figs. 1–3. An anomalous vascular structure running within the right atrio-ventricular groove along with the right coronary artery connecting the right atrium and the coronary sinus (arrows) are presented in Figs. 1–5. A mixed plaques in the proximal LAD with less than 50% luminal stenosis (double arrows) is visualized in Fig. 6.**

Double Flash scan with single contrast bolus for triple rule out

Adriano Camargo de Castro Carneiro, MD[1];Tiago Augusto Magalhães, PhD, MD[1]; Valéria de Melo Moreira, MD[1]; Mariana Macedo Lamacié, MSc, MD[1]; Helder Jorge de Andrade Gomes, MD[1]; Paulo César Ferraz Dias Filho, MD[1]; Matheus de Souza Freitas, MD[1]; Fábio Vieira Fernandes, MD[1]; Bernardo Noya Alves de Abreu, MD[1]; Juliana Hiromi Silva Matsumoto Bello, MD[1]; Carlos Eduardo Elias dos Prazeres, MD[1]; Saulo de Tarso Oliveira Cantoni, MD[2]; Hilton Muniz Leão Filho, MD[2]; Caroline Bastida de Paula, BD[3]; Dany Jasinowodolinski, MD[2], and Carlos Eduardo Rochitte, PhD, MD[1]

[1] Department of Cardiovascular CT and MRI of the Heart Hospital (HCor), São Paulo, Brazil;
[2] Department of Radiology of the Heart Hospital (HCor), São Paulo, Brazil;
[3] Siemens Healthineers, Brazil



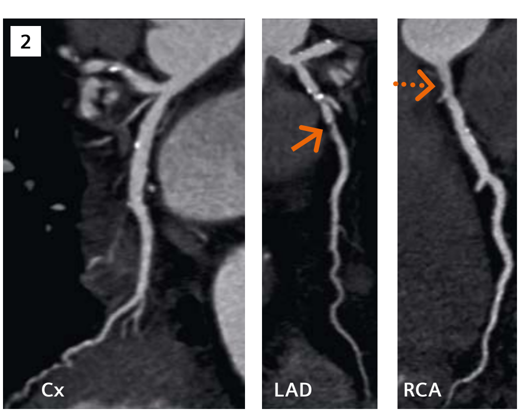
1 **VRT images show the normal pulmonary arteries.**

History

A 76-year-old male patient, with a known history of hypertension and dyslipidemia, was presented to the emergency department complaining of acute retrosternal chest pressure. The pressure began three hours previously, radiated to the back, was accompanied by dyspnea, nausea and profuse perspiration and lasted for 20 minutes. The initial electrocardiogram and biomarkers were normal. A CT examination was requested to rule out coronary artery disease, pulmonary embolism and/or aortic dissection (triple rule out).

Diagnosis

The images acquired from the initial Flash scan showed contrast enhancement solely in the pulmonary arteries with no signs of pulmonary embolism (Fig. 1). The coronary CT angiography (cCTA) images, acquired from the second Flash scan, showed a moderate stenosis in the left anterior descending artery (LAD) and a mild stenosis in the proximal right coronary artery (RCA) (Figs. 2 and 3). No stenosis was seen in the left main coronary artery (LM) nor in the left circumflex artery (Cx). An Agatston calcium score of 154 was calculated. There were no signs of aortic dissection (Fig. 4).The patient was diagnosed with unstable angina and was referred for an interventional coronary arteriogram which confirmed the moderate stenosis in the LAD. A drug-eluting stent was implanted and the patient recovered uneventfully.

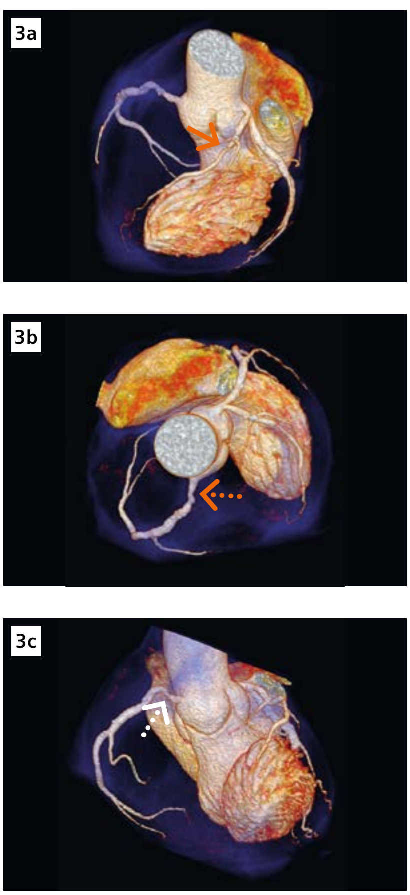


2 **Curved MPR images show a moderate stenosis in the proximal LAD (arrow), a mild stenosis in the proximal RCA (dashed arrow), and multiple calcified plaques in all three coronary arteries.**

Comments

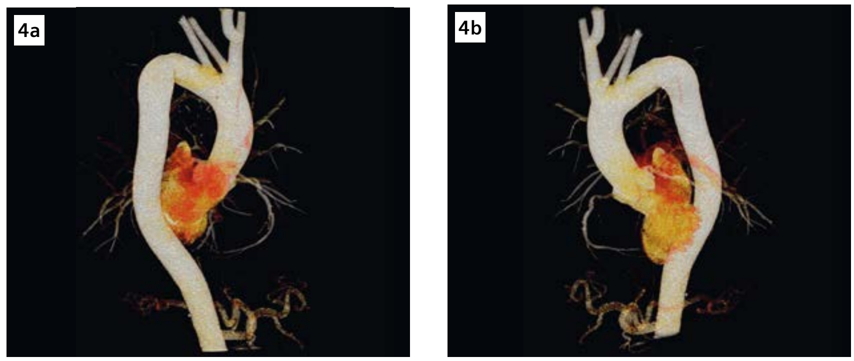
cCTA has become a reliable, non-invasive imaging method for ruling out suspected coronary stenosis. However, in the emergency department, a triple-rule-out protocol for simultaneous evaluation of life-threatening conditions such as acute coronary syndromes, acute aortic syndromes and pulmonary embolism has unclear indications in the present guidelines. Multiple CT examinations require more contrast volume and result in higher radiation exposure and in compromised image quality.

In this case, a double Flash scan protocol was introduced to reduce the scan time (0.72 s), the radiation dose (5.5 mSv) and the volume of contrast agent used (60 mL). An initial test bolus with 10 mL of contrast was used to determine the peak enhancement in the pulmonary trunk and in the ascending aorta. Four seconds were added to the peak enhancement time so as to determine the start delay time. A double Flash scan of the thorax was then performed using only 60 mL of contrast. The first scan (cranio-caudal) was aimed at acquiring images with contrast enhancement only in the pulmonary arteries, whereas the second scan (caudo-cranial) was to acquire images with contrast enhancement in the coronary arteries and the aorta. Taking into consideration that the patient had a moderate calcium score, a higher kV was applied in the second Flash scan to avoid potential beam hardening artifacts caused by calcified plaques in the coronary arteries.



3 **VRT images show a moderate stenosis in the proximal LAD (Fig. 3a, arrow), a mild stenosis in the proximal RCA (Figs. 3b and 3c, dashed arrow).**

All three vascular systems were successfully evaluated, which reduced the patient's time to diagnosis, time to stay and, in the long run, the costs to the emergency department. ●



4 **VRT images reveal a normal aorta.**

Examination Protocol

Scanner	SOMATOM Definition Flash	
Scan area	Thorax (pulmonary arteries)	Thorax (heart and aorta)
Scan mode	Flash mode	Flash mode
Scan length	329.2 mm	329.2 mm
Scan direction	Cranio-caudal	Caudo-cranial
Scan time	0.72 s	0.72 s
Tube voltage	100 kV	120 kV
Effective mAs	370 mAs	400 mAs
Dose modulation	CARE Dose4D	CARE Dose4D
$CTDI_{vol}$	3.59 mGy	6.48 mGy
DLP	140 mGy*cm	254 mGy*cm
Effective dose	1.95 mSv	3.55 mSv
Rotation time	0.28 s	0.28 s
Pitch	3.4	3.4
Slice collimation	128 × 0.6 mm	128 × 0.6 mm
Slice width	0.6 mm	0.6 mm
Reconstruction increment	0.4 mm	0.4 mm
Reconstruction kernel	B26f, I26f	B26f, I26f
Heart rate	55–61 bpm	50–61 bpm

Contrast	
Volume	60 mL
Flow rate	5 mL/s
Start delay	Test bolus (pulmonary trunk) + 4 s
Test bolus	(ascending aorta) + 4 s

D-Transposition of the great arteries – CT evaluation of a newborn

Pannee Visrutaratna, MD, and Wai Leng, Chin[1]
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[1] Siemens Healthineers, RHQ Singapore

History

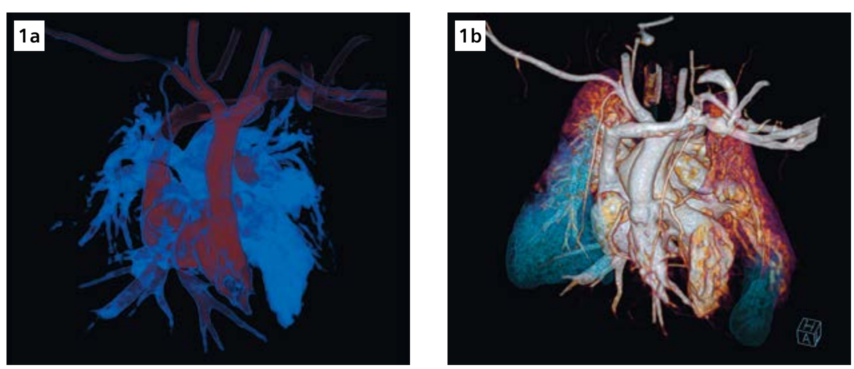
A 13-day-old female newborn suffering from desaturation was scheduled for a surgical operation on an arterial switch. A cardiac CT scan was ordered to evaluate the anatomy of the heart, the great vessels and the coronary arteries prior to the operation.

Diagnosis

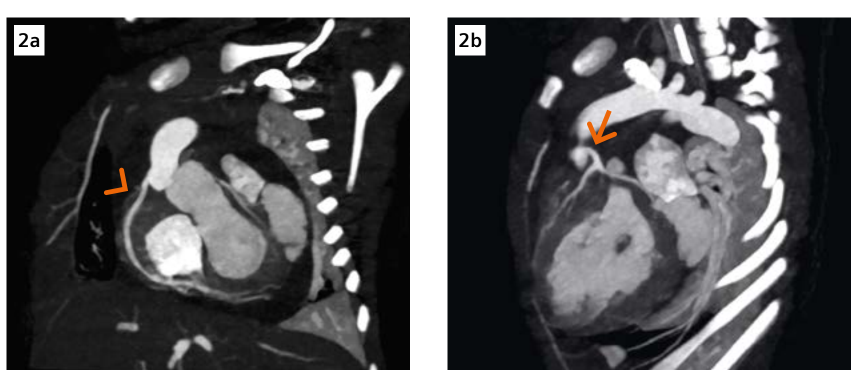
CT images showed a dextro-transposition of the great arteries (d-TGA) with a usual type of the coronary arteries. The aorta, originating from the right ventricle (RV), was anterior and to the right of the pulmonary trunk which originated from the left ventricle (LV) and was enlarged. A cardiomegaly with an atrial septal defect (ASD), a ventricular septal defect (VSD) and a patent ductus arteriosus (PDA) were seen along with a juxta-ductal type coarction of the aorta with hypoplastic aortic arch. Bilateral hyperattenuation in the posterior lung sections was present, suggesting pulmonary edema.

Comments

Cardiac CT scan on a newborn is always challenging due to a higher heart rate and difficulties in breath-hold. In this case, an ultrafast scan mode, the Turbo Flash mode with a scan speed of 737 mm/s, was performed, enabling an acquisition of 98 mm in 0.13 s. The newborn was free-breathing during the scan. A fast true temporal resolution of 66 ms provided by dual source CT allowed an ECG-triggering in the systolic phase (at 35% RR) and maintained an excellent image quality to depict all three coronary arteries despite the infant's higher heart rate (142 bpm). The 70 kV, selected automatically by CARE kV (automated dose-optimized selection of X-ray tube voltage), allowed for an excellent enhancement with only 6 mL of contrast agent. The combination of all these advanced techniques contributed to a confident diagnosis with a very low radiation dose (0.72 mSv). ●



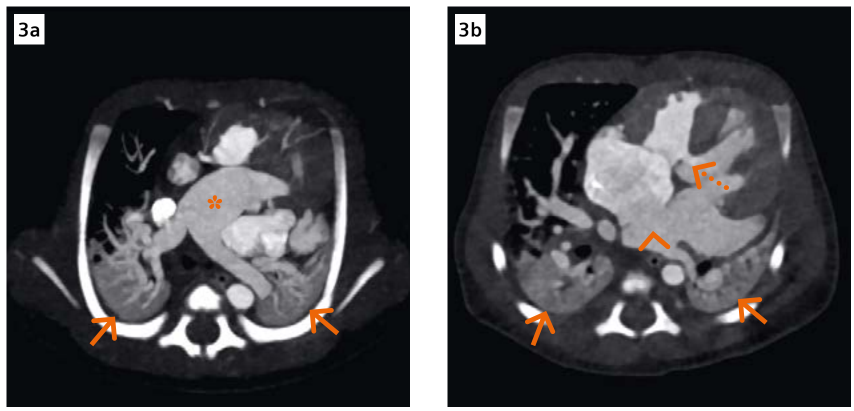
1 VRT images show a d-TGA with the aorta originating from the RV, and the pulmonary trunk from the LV. Coronary arteries are with normal pattern.

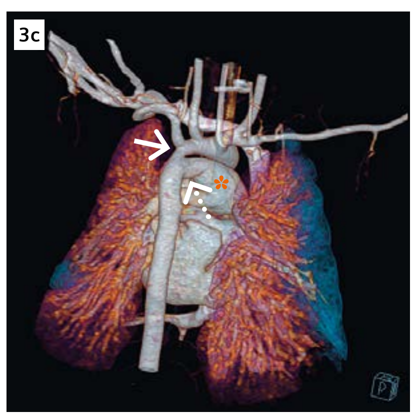


2 MIP images (Fig. 2a, 5 mm; Fig. 2b, 8 mm) show the right coronary artery (Fig. 2a, arrowhead) and the left main coronary artery (Fig. 2b, arrow) branching into the left anterior descending and left circumflex arteries.

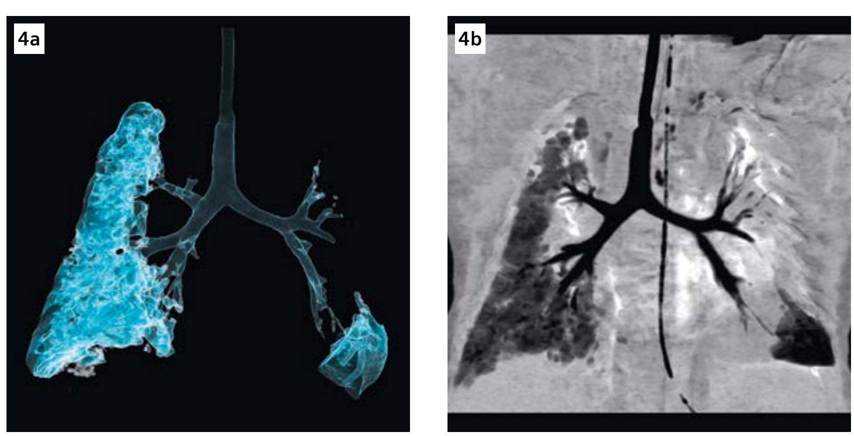
Examination Protocol

Scanner	SOMATOM Force
Scan area	Thorax to upper abdomen
Scan mode	Turbo Flash mode
Scan length	97.5 mm
Scan direction	Cranio-caudal
Scan time	0.13 s
Tube voltage	70 kV
Effective mAs	160 mAs/rot.
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.45 mGy
DLP	6.9 mGy cm
Effective dose	0.72 mSv
Rotation time	0.25 s
Pitch	3.2
Table speed	737 mm/s
Slice collimation	192 × 0.6 mm
Slice width	0.6 mm
Reconstruction increment	0.3 mm
Reconstruction kernel	Bv40
Heart rate	142 bpm
Contrast	
Volume	6 mL
Flow rate	0.7 mL/s
Start delay	CARE Bolus





3 MIP (Figs. 3a and 3b) and VRT (Fig. 3c) images show that the ascending aorta is anterior and to the right of the enlarged pulmonary trunk (asterisk). An ASD (arrowhead), a VSD (dashed arrow), aortic coarctation (white arrow) with a PDA (white dashed arrow), and hyperattenuation in both posterior lungs (arrows) are present.



4 VRT (Fig. 4a) and MinIP (Fig. 4b) images show a normal bronchial tree with limited volume of inflated lungs.

Evaluation of Williams-Beuren Syndrome in a two-month-old child using a single rotation scan mode

Hans-Christoph Becker, MD
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History

A two-month-old boy, with known Williams-Beuren syndrome, was presented to the hospital for surgical repair. Prior to surgery, a CT scan was ordered to evaluate the cardiovascular structures. The main focus was to define the origin of the coronary arteries relative to the aortic stenosis.

Diagnosis

CT images clearly showed a significant stenosis of the ascending aorta directly above the aortic root. Both coronary arteries originated slightly below the stenosis. A dysplastic right pulmonary artery and a very small fistula were also seen between the descending aorta and the right upper pulmonary vein.

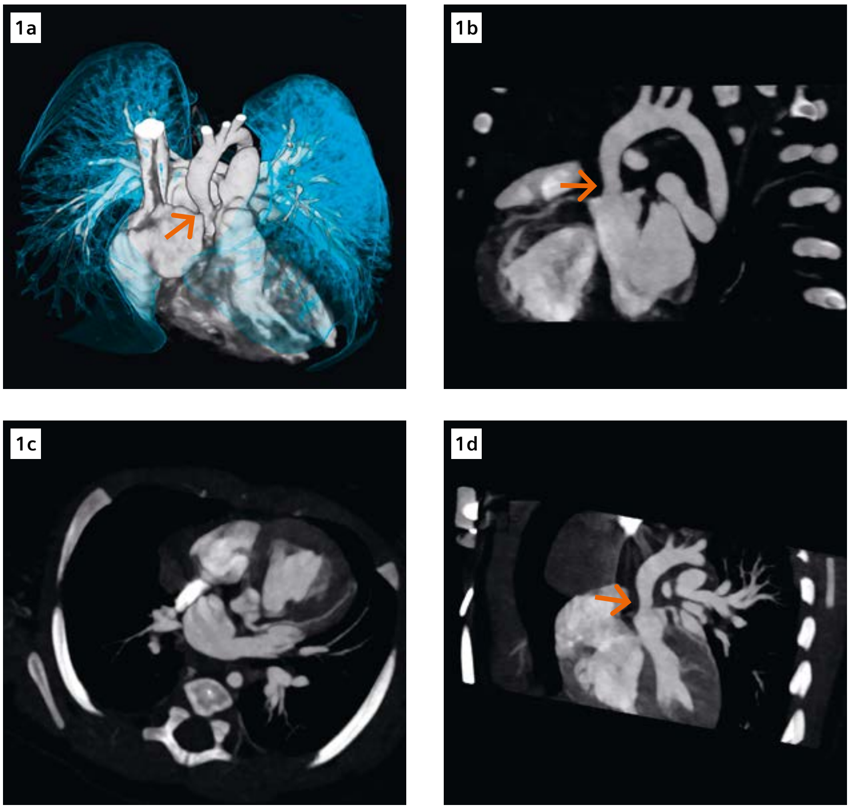
Comments

CT scans are routinely used for cardiovascular evaluations. In this case, the CT aided in the planning of the surgical correction of the aortic stenosis, also demonstrating that resection and re-insertion of the coronary arteries would not be necessary. Furthermore, it also showed a dysplastic right pulmonary artery and a very small DAPVF (descending aorta-pulmonary vein fistula), which would have not been echocardiographically detected.

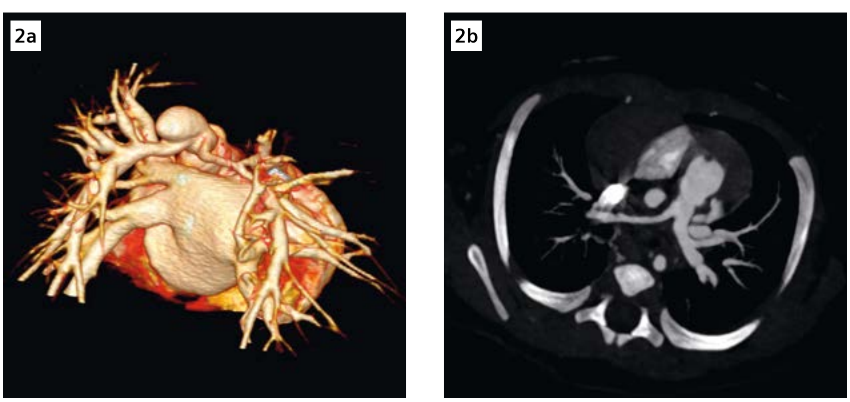
One of the challenges of performing a CT scan on a baby, with a heart rate of 153 bpm, was to complete scanning as quickly as possible. Therefore, a single rotation scan mode was applied to acquire the whole heart in just 0.15 s. This resulted in an excellent image quality without motion artifact even though the baby was free breathing during the scanning. Taking into consideration the exposure dose for the baby, 70 kV was selected to achieve a DLP of only 12 mGy*cm. This scan mode is routinely applied in our department on small size babies. ●

Examination Protocol

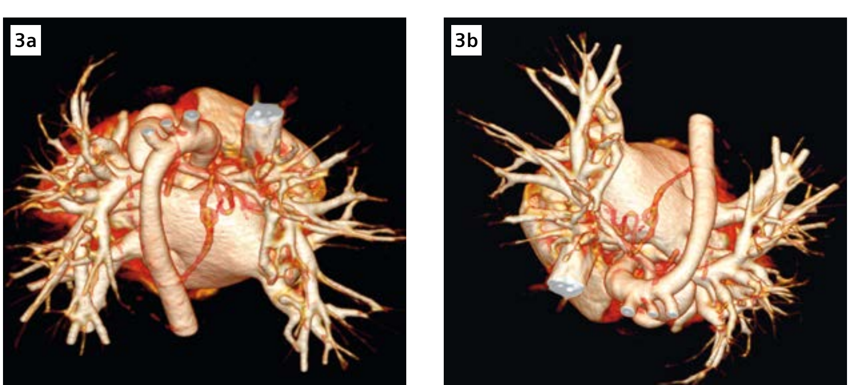
Scanner	SOMATOM Force
Scan area	Heart
Scan mode	Single rotation
Scan length	46.8 mm
Scan direction	Cranio-caudal
Scan time	0.15 s
Tube voltage	70 kV
Effective mAs	376 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	2.09 mGy
DLP	12 mGy*cm
Effective dose	1.12 mSv
Rotation time	0.25 s
Slice collimation	192 × 0.6 mm
Slice width	0.6 mm
Reconstruction kernel	Bv40 ADMIRE
Heart rate	153 bpm
Contrast	400 mg / mL
Volume	5 mL + 20 mL saline
Flow rate	0.5 mL/s
Start delay	2 s after the contrast arrival at the ascending aorta



1 A VRT (Fig. 1a) and three MIP (Figs. 1b, 1c and 1d) images show a significant stenosis (arrows) of the ascending aorta directly above the aortic root. Both coronary arteries originate slightly below the stenosis.



2 VRT (Fig. 2a) and MIP (Fig. 2b) images show a dysplastic right pulmonary artery.



3 VRT images show a DAPVF from two different views.

Transposition of the great arteries with multiple interventricular communications and anomaly of the coronary arteries

Valéria de Melo Moreira, MD, Adriano Camargo de Castro Carneiro, MD, Tiago Augusto Magalhães, PhD, MD, Juliana Hiromi Silva Matsumoto Bello, MD, Carlos Eduardo Elias dos Prazeres, MD, Caroline Bastida de Paula, BM and Carlos Eduardo Rochitte, PhD, MD
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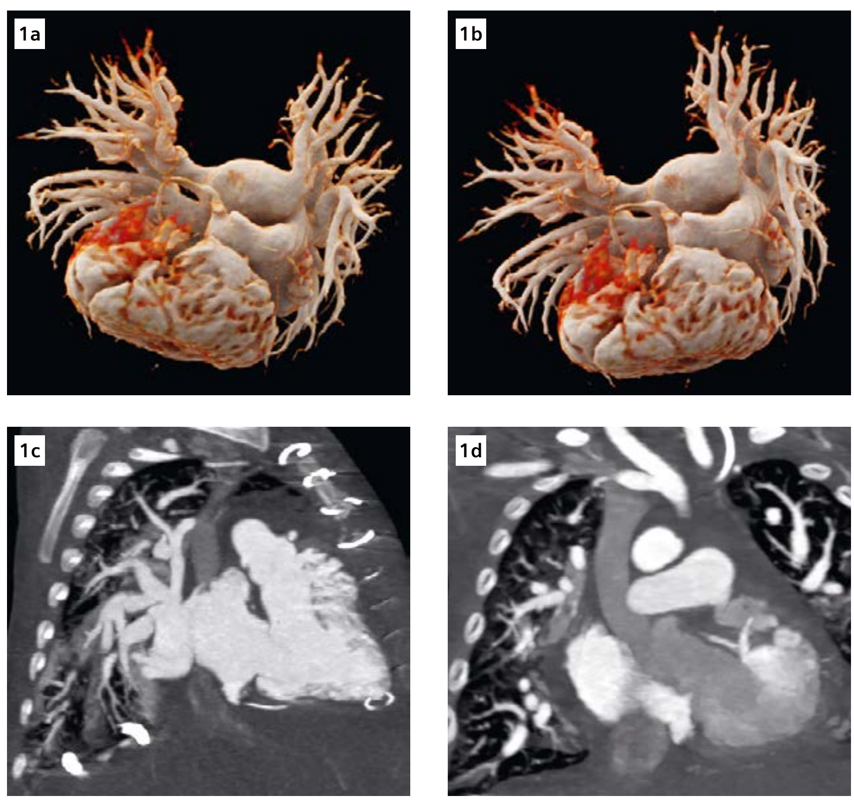
History

A neonate was born with a diagnosis of transposition of the great arteries (TGA) and isolated sub-pulmonary ventricular septal defect (VSD). A postnatal echocardiogram confirmed the diagnosis and additionally revealed an anomaly of the coronary arteries. In view of the cardiac anatomy, spatial arrangement of the great vessels associated with the coronary anomaly, a surgical palliation with pulmonary artery (PA) banding and atrioseptostomy was performed on day 14 after birth. Seven months later, the patient returned for scheduled Senning surgery. Clinical examination revealed an ejection systolic cardiac murmur in the left upper sternal border and cyanosis with blood oxygen saturation of 75% at room air. Senning surgery was performed with ventriculoseptoplasty and removal of PA banding.

In the postoperative period, the patient developed complications, including significant worsening of the respiratory condition and difficulties in extubation. Postoperative echocardiography showed a suspicious cava baffle stenosis. Cardiovascular CT was requested to evaluate intra-atrial baffle abnormalities.

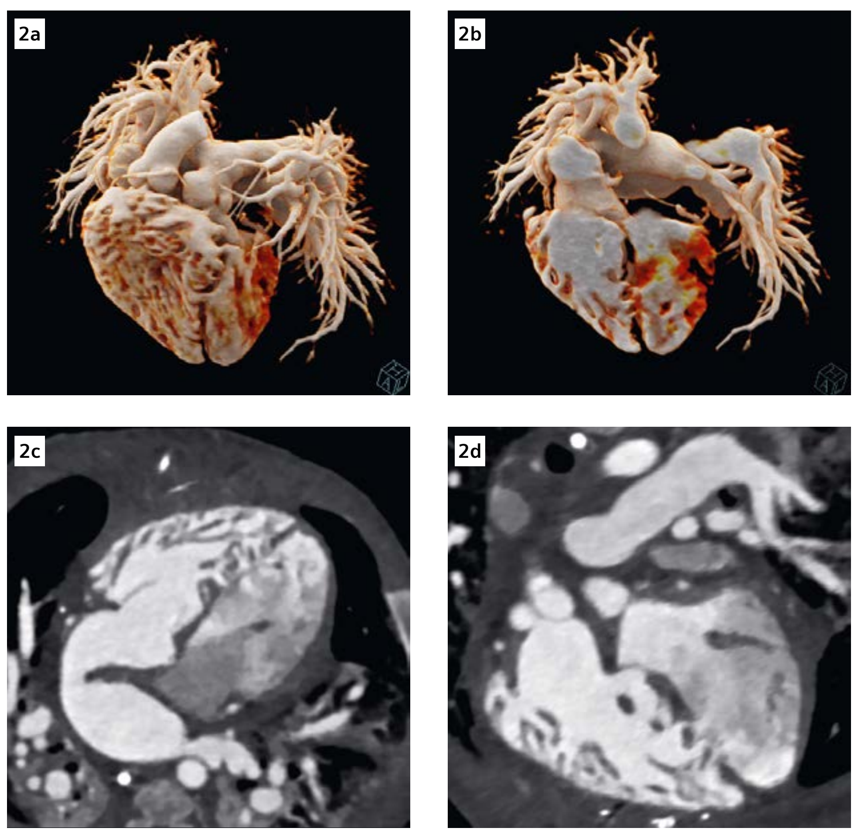


1 **Cinematic rendering (Figs. 1a and 1b) and MIP (Figs. 1c and 1d) images show a satisfactory surgical result without significant luminal reduction points in the topography of the pulmonary veins and cava vein tunnels.**

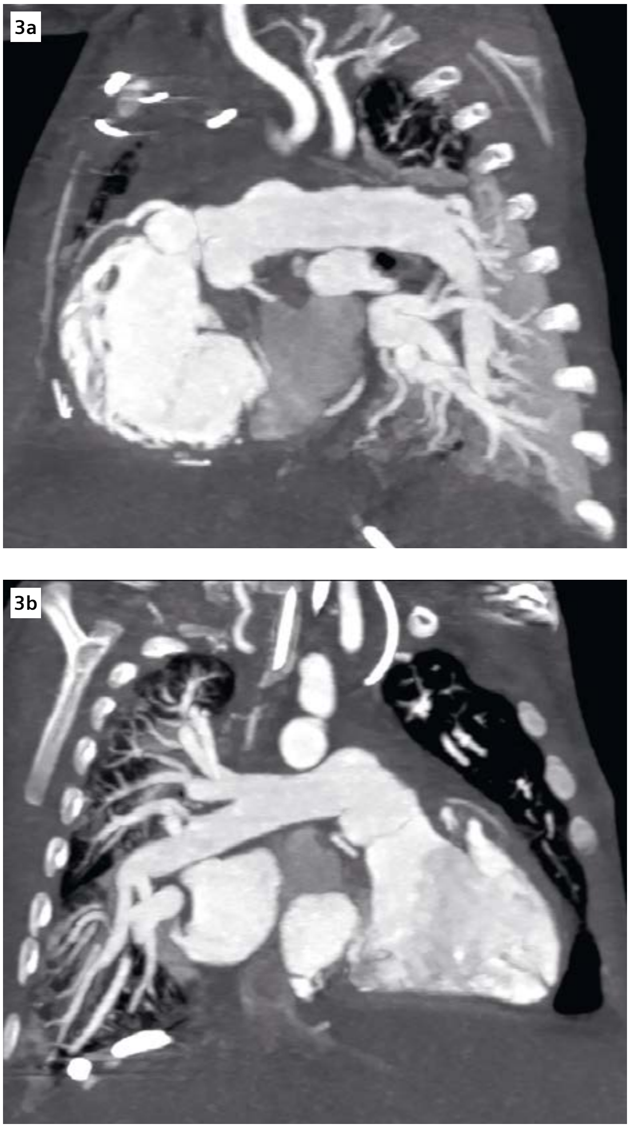
Diagnosis

CT images showed a satisfactory surgical result without significant luminal reduction points in the topography of the pulmonary veins and cava vein tunnels (Fig. 1). An extremely complex interventricular septum with multiple VSDs (Fig. 2) and a severe hemodynamic repercussion were evidenced.
The pulmonary arteries were significantly dilated with patterns of pulmonary parenchyma congestion (Fig. 3).The coronary anomaly (Fig. 4a) and a successful patch (Fig. 4b) of a VSD were confirmed.

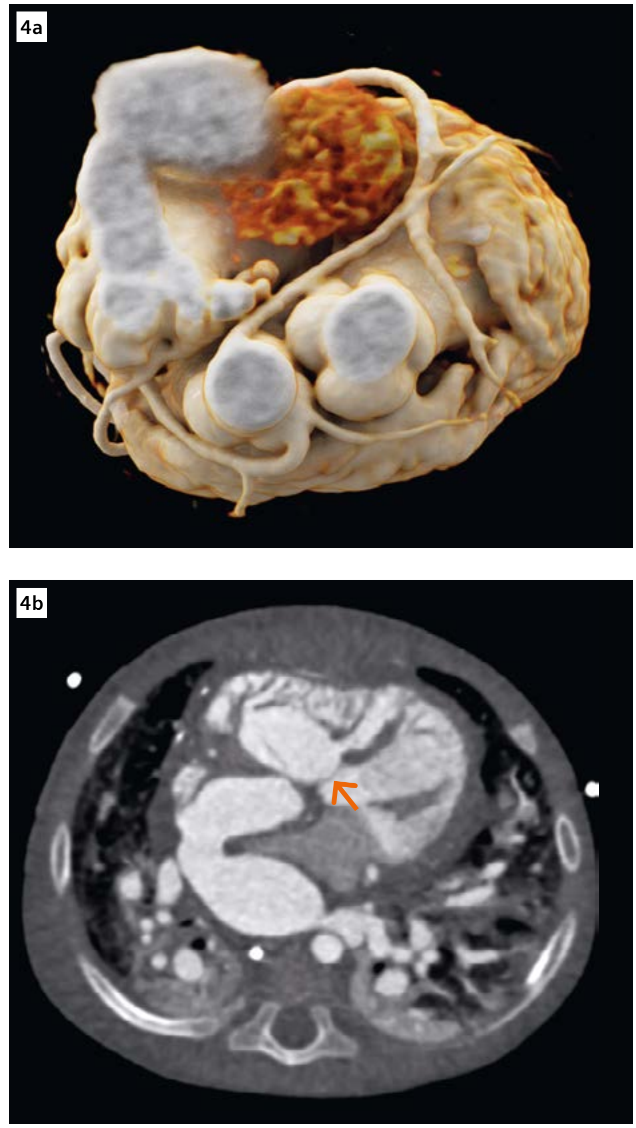
PA rebanding was performed to reduce the pulmonary hyperflow. The mechanical ventilation was successfully withdrawn and the patient was discharged from the hospital.



2 **Cinematic rendering (Figs. 2a and 2b) and MPR (Figs. 2c and 2d) images show an extremely complex interventricular septum with multiple ventricular septal defects.**



3 MIP images demonstrate a significant dilation of the pulmonary arteries and pulmonary parenchyma congestion pattern.



4 Cinematic rendering (Fig. 4a) and MPR (Fig. 4b) images show the coronary anomaly (Fig. 4c) and a successful VSD patch (Fig. 4b, arrow).

Comments

TGA is a congenital cardiac malformation characterized by atrioventricular concordance and ventriculoarterial discordance. The association with other cardiac malformations such as ventricular septal defect and coronary anomalies may occur and defines clinical presentations and surgical management. The Senning procedure is an atrial switch operation diverting the venous drainage. It is an alternative surgical approach when the Jatene arterial switch operation is not feasible.[1-7]

Multiple interventricular communications ("Swiss cheese" septal defects) often become a therapeutic challenge that require precise preoperative imaging for accurate delineation of the location, number, shape and size of the ventricular septal defects and a clear appreciation of understanding the adjacent anatomy.

In this case, CT images demonstrated complex muscular ventricular septal defects, which had not previously been diagnosed by echocardiography. This finding was not favorable for treatment strategies such as device closure or a surgical procedure.

Using the advanced technologies such as scanning speed and radiation dose reduction, CT has become a complementary diagnostic tool in challenging pediatric cardiac cases with complex anatomical scenario. In this case, the entire cardiac acquisition was completed in 0.27 seconds at free breathing using Turbo Flash mode. A combination of dose reduction techniques, such as CARE Dose4D (real-time anatomic exposure control) and SAFIRE (sinogram affirmed iterative reconstruction) were integrated to achieve an effective dose as low as 0.9 mSv. ●

Examination Protocol

Scanner	**SOMATOM Definition Flash**
Scan area	Thorax
Scan mode	Flash mode
Scan length	122.4 mm
Scan direction	Cranio-caudal
Scan time	0.27 s
Tube voltage	80 / 80 kV
Effective mAs	200 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.91 mGy
DLP	15 mGy*cm
Effective dose	0.9 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 × 0.6 mm
Slice width	0.6 mm
Reconstruction increment	0.4 mm
Reconstruction kernel	I26f
Heart rate	78 – 85 bpm
Contrast	370 mg/mL
Volume	12 mL
Flow rate	1 mL/s
Start delay	Bolus tracking, manual start

References

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Turner syndrome with aortic coarctation and thin intraluminal obstructive ring: a critical stenosis preserved by iterative reconstruction

Frandics P. Chan, MD, PhD
Department of Radiology, Stanford University Medical Center, California, USA

History

A 7-year-old girl was presented for an evaluation of her small stature when compared to her peers. She was evaluated by an endocrinologist and diagnosed with Turner syndrome. Due to the association of Turner syndrome with cardiovascular abnormalities, an echocardiography was performed. The echocardiography showed a discrete aortic narrowing, consistent with an aortic coarctation. The peak pressure gradient estimated by echocardiography was 50 mmHg. In order to decide between endovascular treatment with angioplasty and stenting versus surgical repair, a CT angiography of the chest was performed to define the length and narrowness of the coarctation, its distance to the cervical arteries, and any stenoses in these arteries. The coarctation was surgically resected and the aorta repaired with an end-to-side connection.

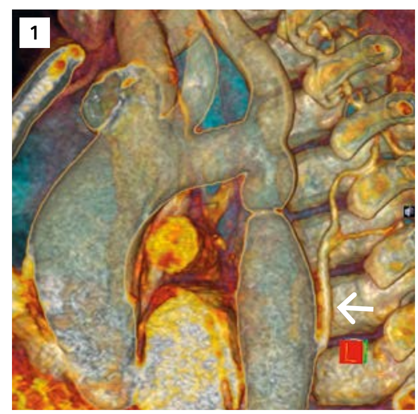
Diagnosis

The aortic arch was right-sided with a normal branching order of the cervical arteries. The coarctation was located distal to the left subclavian artery at the juxtaductal position (Fig. 1). All cervical arteries were patent. Prominent intercostal arteries (arrow) conducted retrograde collateral flow into the distal aorta, bypassing the obstruction. The outer contour of the coarctation had an "hour-glass" shape with a diameter of 9 mm at the waist, but inside the coarctation there was a web-like ring that further narrowed the flow lumen to a diameter of 4 mm (Fig. 2).

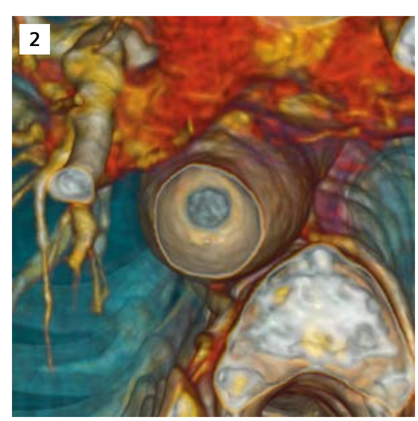
Comments

Turner syndrome is a genetic disease in which the patient has only one copy of the sex-determining chromosome, an X-chromosome, without a second X- or Y-chromosome. Patients with Turner syndrome are phenotypically female. The disease is associated with a number of congenital cardiovascular abnormalities including coarctation of the aorta, bicuspid aortic valve, aortic valve stenosis, partial anomalous pulmonary venous return, and others. Coarctation, which occurs in 17% of these patients, is the most frequent and clinically important abnormality.

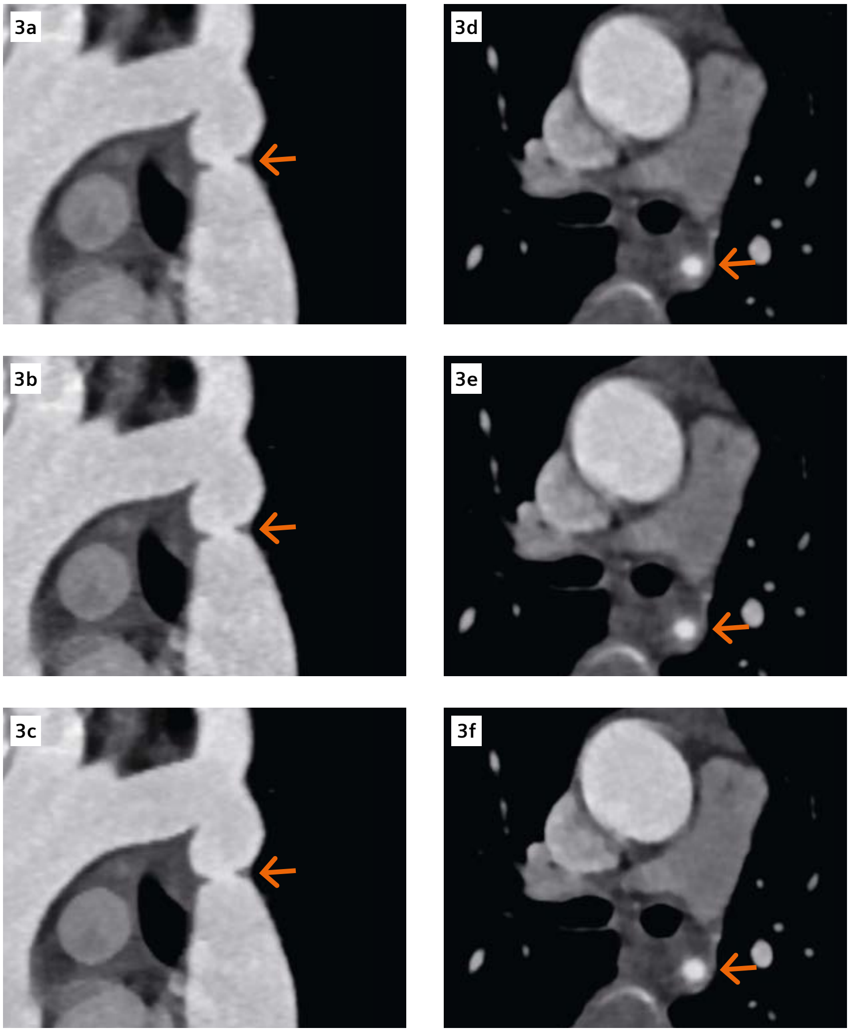
Management guidelines for Turner syndrome include noninvasive imaging, such as echocardiography and MR angiography, to detect coarctation.[1] CT angiography is an alternative examination if MR angiography is contraindicated or high-resolution imaging is needed for endovascular or surgical treatment planning. Surgical repair is preferred in young patients when



1 Volume-rendered view of the aortic arch: Note the hour-glass outer contour and the web-like ring within the flow lumen. A prominent intercostal artery drains into the distal aorta (arrow).



2 Volume-rendered view from the top of the aortic arch: It shows the opening of the intraluminal ring.



3 **Multiplanar reformat of the web-like obstruction (arrows) in the sagittal plane (Figs. 3a–3c) and in the axial plane (Figs. 3d–3f) at different SAFIRE levels: Figs. 3a and 3d: none; Figs. 3b and 3e: SAFIRE level 2; Figs. 3c and 3f: SAFIRE level 4. The geometry of the obstruction is essentially unchanged.**

their aortas have yet to grow to full size. An endovascular approach may be used in older patients with fully developed aortas.

The use of iterative image reconstruction, such as SAFIRE, enables CT scans with reduced radiation dose without associated increase in image noise. However, the image reconstruction must not obscure or alter diagnostically important features. This case demonstrated that an obstructive ring as thin as one millimeter was preserved by SAFIRE (Fig. 3). Accurate representation of a vascular obstruction was important not only for diagnostic assessment and treatment planning, it also enables the calculation of hemodynamic information, such as pressure gradients, shear stress, and ventricular loading by computational fluid dynamics.[2] ●

References

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Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan mode	Flash mode
Scan length	160 mm
Scan direction	Cranio-caudal
Scan time	0.4 s
Tube voltage	80 kV
Effective mAs	60 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.97 mGy
DLP	25 mGy*cm
Effective dose	1 mSv[1]
Rotation time	0.28 s
Pitch	3
Slice collimation	128 × 0.6 mm
Slice width	0.6 mm
Reconstruction increment	0.6 mm
Reconstruction kernel	B26f/I26f (SAFIRE)
Contrast	350 mg/mL
Volume	30 mL
Flow rate	2 mL/s
Start delay	Bolus tracking

[1] Estimated by applying a conversion factor of 0.018, and an additional factor of 2.3 converting the reported DLP (32 cm) into the DLP (16 cm).

Low dose CT diagnosis of pediatric aortic coarctation using CARE kV, SAFIRE, and Flash Mode

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[1] Shandong provincial key laboratory of diagnosis and treatment of cardio-cerebral vascular diseases, Shandong Medical Imaging Research Institute, Shandong University, Jinan, Shandong, P. R. China

[2] Siemens Healthineers, China

History

A 4-year-old boy was presented with a history of hypertension. A physical examination revealed upper extremity hypertension and diminished femoral pulses. A systolic ejection murmur, at the left upper sternal border, radiated to the interscapular area. A cardiovascular CT examination was requested to evaluate the aortic anatomy prior to surgery.

Diagnosis

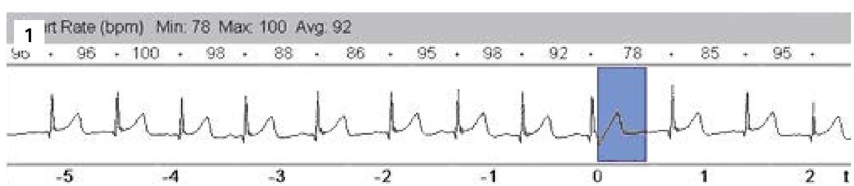
A thoracic CT Angiography (CTA) scan with ECG triggering confirmed the coarctation of the aorta (Figs. 3, 5–8). The coarctation was distal to the left subclavian artery and measured 15 mm in diameter proximal to the obstruction, 5 mm at the smallest diameter, 16 mm distal to the obstruction and 10 mm in length. Additionally, a small patent ductus arteriosus (Figs. 4, 7–8) was found, connecting the main pulmonary artery and the upper descending aorta. The cardiac structures, as well as the origins and the courses of the coronary arteries, showed no abnormalities.

Comments

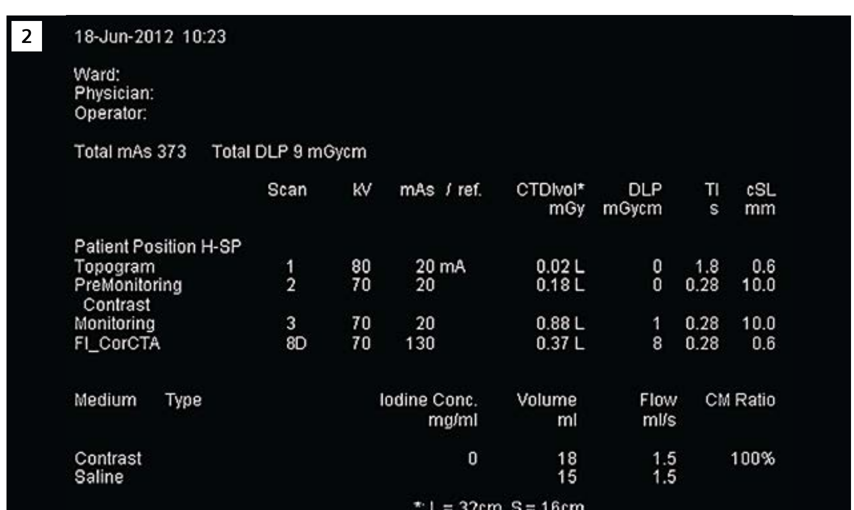
Flash Mode enables an ECG-triggered spiral scan starting at 10% of the R-R interval with a high pitch of 3.4. The heart rate varied between 78 to 100 bpm (Fig. 1), however, the image acquisition of the entire thorax was completed within one cardiac cycle in only 0.46 s. Therefore neither sedation nor breathhold was necessary.

A combination of various techniques was applied to lower the radiation dose to 0.35 mSv – CARE Dose4D (automatic tube current modulation), CARE kV (automatic tube voltage optimization) and SAFIRE (raw data-based iterative reconstruction).

The amount of contrast medium used could also be reduced to 18 mL (1.2 mL per kg body weight) – thanks to the Flash scanning speed and the intensive enhancement achieved at 70 kV. ●



1 Flash Mode enables data acquisition within one cardiac cycle



2

18-Jun-2012 10:23

Ward:
Physician:
Operator:

Total mAs 373   Total DLP 9 mGycm

	Scan	kV	mAs / ref.	CTDIvol* mGy	DLP mGycm	TI s	cSL mm
Patient Position H-SP							
Topogram	1	80	20 mA	0.02 L	0	1.8	0.6
PreMonitoring	2	70	20	0.18 L	0	0.28	10.0
Contrast							
Monitoring	3	70	20	0.88 L	1	0.28	10.0
Fl_CorCTA	8D	70	130	0.37 L	8	0.28	0.6

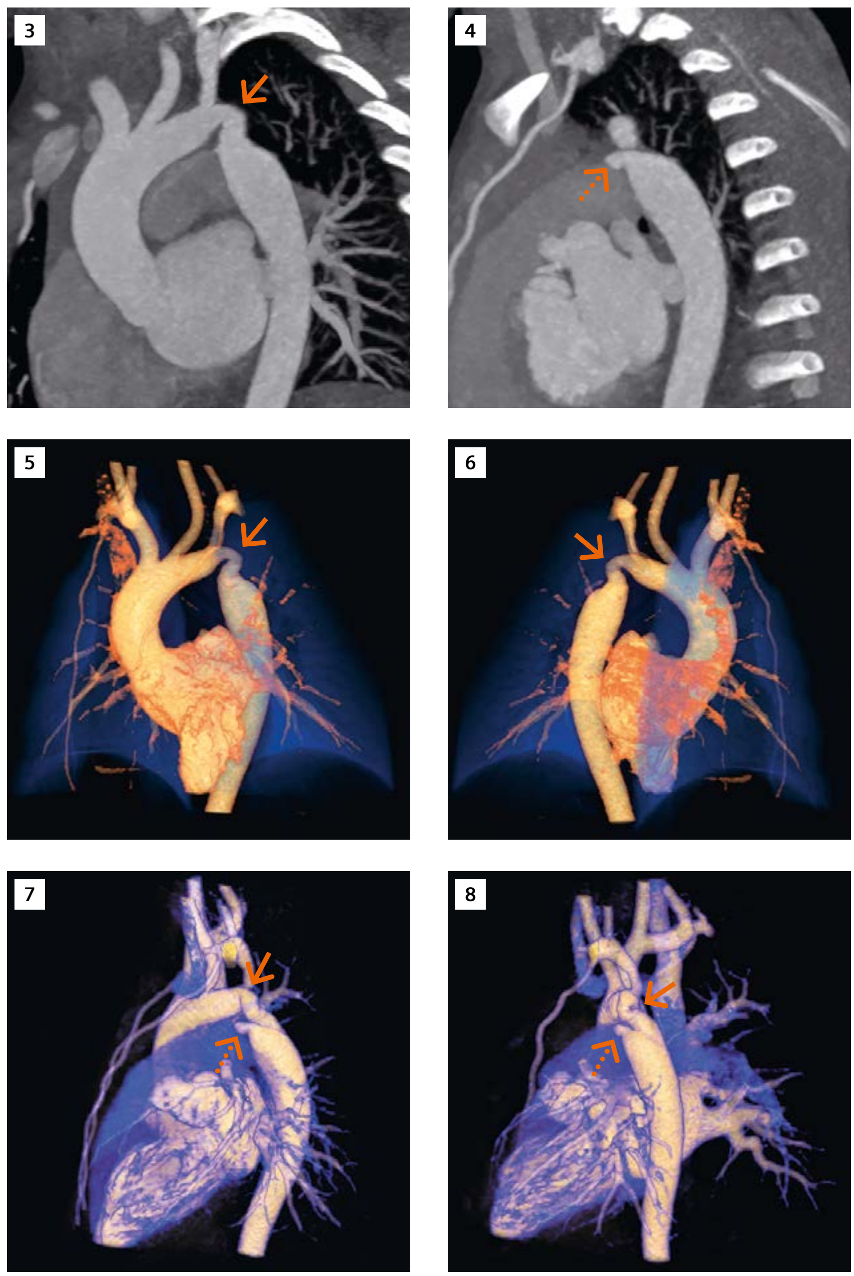
Medium	Type	Iodine Conc. mg/ml	Volume ml	Flow ml/s	CM Ratio
Contrast		0	18	1.5	100%
Saline			15	1.5	

*: L = 32cm, S = 16cm

2 The parameters of CT scanning and contrast injection were recorded in the patient protocol.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan mode	Flash mode
Scan length	144 mm
Scan direction	Caudo-cranial
Scan time	0.32 s
Tube voltage	70 kV with CARE kV
Effective mAs	130 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.37 mGy
DLP	8 mGy*cm
Effective dose	0.35 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 x 0.6 mm
Slice width	0.75 mm
Spatial Resolution	0.33 mm
Reconstruction increment	0.5 mm
Reconstruction kernel	I26f, SAFIRE
Heart rate	78 – 100 bpm
Contrast	350 mg/mL
Volume	18 mL (contrast) + 15 mL (saline)
Flow rate	1.5 mL/s
Start delay	25 s



3–8 **Maximum Intensity Projection (MIP) images (Figs. 3–4) and volume-rendered images (Figs. 5–8) demonstrated the coarctation of the aorta (arrows) and the patent ductus arteriosus (dashed arrows) between the main pulmonary artery and the upper descending aorta.**

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