Triple-rule-out evaluation of acute chest pain using single source photon-counting CT

Lili Száraz, MD; Sámuel Beke, MD; Kristóf Nagy, MD; Barnabás Baksa, MD; Péter Hegedűs, MD, PhD; Prof. Pál Maurovich-Horvat, MD, PhD

Medical Imaging Centre, Semmelweis University, Budapest, Hungary

History

A 50-year-old male patient presented to the emergency department (ED) with massive hemoptysis, dyspnea, and chest pain. The patient's medical history included multiple cardiac risk factors and adverse events, including hypertension, chronic obstructive pulmonary disease, previous myocardial infarction, and mitral valvuloplasty. Notable physical exam findings included tachypnea, spastic respiratory sounds with left-sided crepitations, and diaphoretic skin. Laboratory findings revealed elevated inflammatory markers, high-sensitivity Troponin T, and D-dimer levels. Given the high suspicion of pulmonary embolism (PE), a targeted chest CT angiography (CTA) was performed, using ECG-gated helical acquisition with standard-resolution scan mode, to confirm the PE and evaluate the bronchial arteries, guiding further potential embolization therapy.

Diagnosis

The multiphase chest CTA confirmed a left-sided PE complicated by infarct pneumonia (see Figure 2). Thrombolytic therapy was not indicated, as determined in consultation with the intensive care unit. Likewise, bronchial artery embolization was considered unnecessary, since the hemoptysis was attributed to the severe infarct pneumonia. Empirical antibiotic therapy was initiated and later escalated to a combination of piperacillin–tazobactam and metronidazole. Due to significant hemoptysis, anticoagulation was administered at a reduced dose; nevertheless, anti-Xa levels remained within the therapeutic range. The chest CTA additionally revealed a left hilar mass infiltrating the pulmonary branches of the left lower lobe (see Figure 2), as well as a smaller, round lesion closely adherent to the pericardium at the base of the right lung. On a one-month follow-up scan, the left-sided mass had resolved, while the right-sided benign-appearing lesion remained unchanged. On a three-month follow-up scan, no malignancy was found, the atelectasis and consolidations showed signs of regression, however the segmental and subsegmental emboli were still visible.

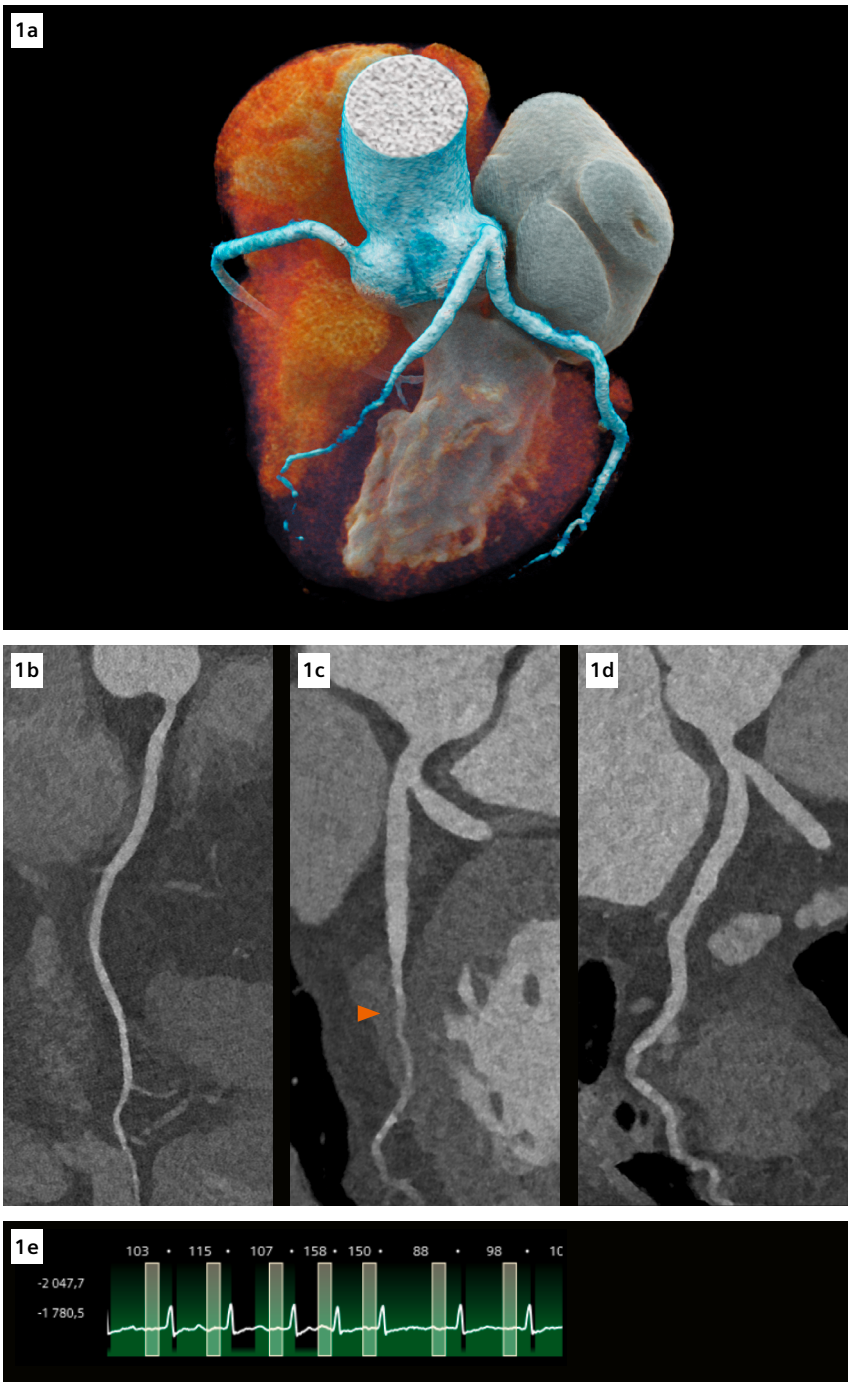
Comments

While the ability of triple-rule-out-CT (TRO-CT) to rule out disorders in all three vascular beds (pulmonary embolism, PE; aortic dissection, AD; and coronary artery disease, CAD) has been demonstrated [1], a gap remains in the literature regarding the clinical impact of TRO-CT. Araoz P.A. et al. found that, based on accepted clinical risk scores, 65% of their patient cohort warranted work-up for at least two of either PE, AD or CAD suggesting that a large subset of patients would benefit from a comprehensive test like TRO-CT [2], even though the mean radiation dose (23.8 ± 12 mSv; range: 3.7–84.1 mSv) and contrast media usage (144.6 ± 31.2 mL; range: 54-360 mL) varied widely. On the other hand, Takx et al. found that TRO-CT may reduce the length of stay and costs in ED in appropriate patients, but no difference in the diagnosis of PE, AD, or CAD was observed between TRO-CT versus standard-of-care strategies [3]. Currently, no major US or EU guidelines recommend routine TRO-CT as the initial ED test for undifferentiated acute chest pain, due to the limited contemporary comparative evidence. This case report serves as a reference, suggesting that PCD-CT may help revive the TRO-CT paradigm.

In this case, the targeted chest CTA enabled the use of a TRO-CT equivalent methodology. Therefore, the entire thoracic aorta was included in the scan range and timing was set to achieve optimal enhancement in the aorta and pulmonary arteries. Due to the high spatial resolution of the photon-counting detector, the coronary arteries could also be accurately evaluated.

The fine spatial detail (0.4 mm slice thickness) enabled an accurate evaluation of the coronary arteries to rule out severe CAD (as part of the differential diagnosis of chest pain) (see Figure 1). The use of advanced image reconstruction algorithms,

such as ZeeFree, combined with the preview series function, resulted in only minor motion artifacts on the acquired scans, despite the high heart rate variability (Minimum: 86, Maximum: 158, average: 110). Detector-based quantum spectral imaging capabilities (lung analysis reconstruction) made it impressively fast to detect lung perfusion deficits caused by the PE and aided further therapy decision-making by down-grading disease severity. A fair dose length product (636 mGy*cm) was achieved during the chest CTA, utilizing the NAEOTOM Alpha.Prime CT scanner with an optimized protocol, serving as a true "one-stop-shop" TRO-CT examination. ●



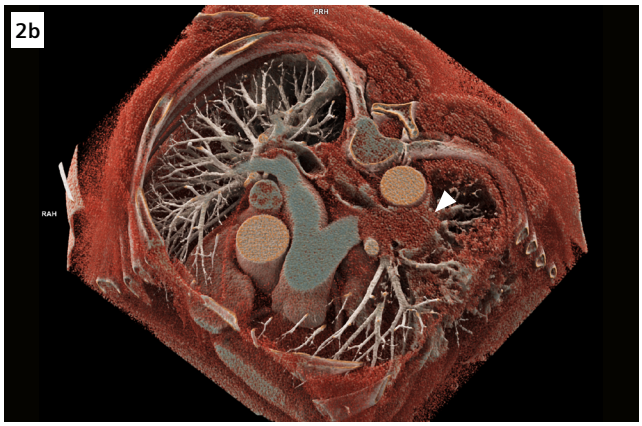
1 **Cinematic volume rendering technique (cVRT) image of the heart (a) and curved multiplanar reconstructions of the coronary arteries (b-d). (b) represents the right coronary artery, (c) represents the left main and left anterior descending (LAD) coronary artery, while (d) represents the left main and left circumflex coronary artery. The arrow indicates a complete myocardial bridge on the middle LAD. Note the excellent visualization of the coronary arteries despite high and irregular heart rate (e).**

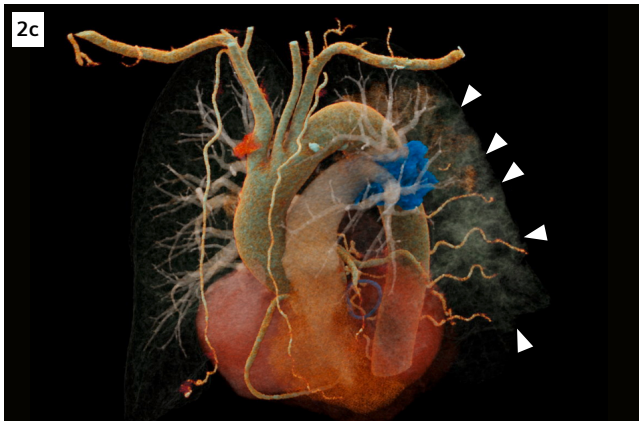
References

[1] Takakuwa, K.M. and E.J. Halpern, Evaluation of a "triple rule-out" coronary CT angiography protocol: use of 64-Section CT in low-to-moderate risk emergency department patients suspected of having acute coronary syndrome. Radiology, 2008. 248(2): p. 438–46.

[2] Araoz, P.A., et al., Triple Rule Out CT in the Emergency Department: Clinical Risk and Outcomes (Triple Rule Out in the Emergency Department). Acad Radiol, 2025. 32(3): p. 1297–1305.

[3] Takx, R.A.P., et al., In-Hospital Cost Comparison of Triple-Rule-Out Computed Tomography Angiography Versus Standard of Care in Patients With Acute Chest Pain. J Thorac Imaging, 2020. 35(3): p. 198–203.





2 Coronal maximum intensity projection (MIP) image of the pulmonary vasculature (a) demonstrates a filling defect in the lower part of the left pulmonary artery. Volume rendering technique (VRT) reconstructions (b, c) depict the pulmonary vessel arborization: In (b), a cross-sectional view, the filling defect is visible in the left pulmonary artery (arrow). In (c), an oblique view, the embolus is highlighted in blue, while the consolidations in the lung can also be appreciated (small arrows).

Examination Protocol

Scanner	NAEOTOM Alpha.Prime
Scan area	Chest
Scan mode	QuantumPlus
Scan length	325.95 mm
Scan direction	Cranio-caudal
Scan time	4.881 s
Tube voltage	140 kV
Effective mAs	281.15 mAs
IQ level	64
Dose modulation	CARE Dose4D
$CTDI_{vol}$	22.4 mGy
DLP	636 mGy*cm
Rotation time	0.25 s
Pitch	0.29
Slice collimation	0.40 mm
Slice width	57.60 mm
Reconstruction increment	0.2 mm (cardiac), 1 mm (lung)
Reconstruction kernel	Bv44 (cardiac), Qr40 (lung)
keV level	70 (cardiac), 55 (lung)
Spectral reconstruction	VMI, Lung Analysis, VNC, Iodine
Heart rate	110 (range: 86–158)

Contrast	350 mg/mL
Volume	80 mL + 50 mL saline
Flow rate	4.5 mL/s
Start delay	Bolus tracking triggered at 200 HU in the ascending aorta

The statements by customers of Siemens Healthineers described herein are based on results that were achieved in the customer's unique setting. Because there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT and/or automation adoption) there can be no guarantee that other customers will achieve the same results.

The products/features (mentioned herein) are not commercially available in all countries. Their future availability cannot be guaranteed.