Follow-up of an acute pulmonary embolism in an obese patient with an unknown patent foramen ovale

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History

A 38-year-old female obese patient (165 cm height, 109 kg weight, BMI 40) suffered from an acute pulmonary embolism (PE) eighteen months ago. Her medical history included severe thrombotic context with several episodes of extensive lower extremity phlebitis, venous thrombosis and cryptogenic stroke. Despite adequate anticoagulant treatment of the acute PE episode, her dyspnea persisted. The patient was referred for a CT pulmonary angiography (CTPA) to clarify a potential evolution towards chronic pulmonary embolism.

Diagnosis

CTPA images displayed at 70 keV (equivalent to a standard 120 kV acquisition) showed a poor opacification of the pulmonary arteries (158 HU within the pulmonary trunk) and a good opacification in the aorta, indicating the potential existence of a patent foramen ovale (PFO) with a right-to-left shunt. The upper and lower thirds of the acquisition were not affected despite this shunt – the segmental artery of the right upper lobe (RA1), previously obstructed and dilated by the acute thrombus, presented severe stenosis, confirming focal chronic PE. A clot in the lateral segmental artery of the right lower lobe (RA9) was persistently seen. However, in the middle third of the acquisition, the opacification in the pulmonary arteries (PA) was insufficient and slightly heterogeneous, raising concerns about persistent clots in the left interlobar PA and bilateral proximal lower lobe PAs. When switching image display from 70 keV to 40 keV, the attenuation within the pulmonary trunk (457 HU), as well as in the segmental PAs, was restored to a diagnostic level and the absence of residual clots could be confirmed.

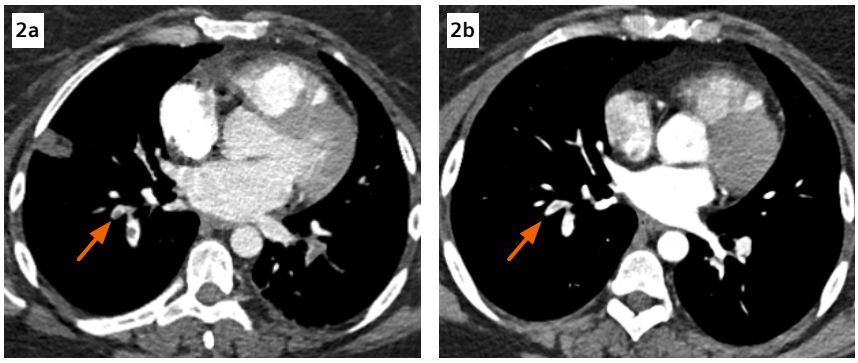
Based on CT findings, the treating physician considered that the patient was resistant to the anticoagulant she had been receiving since previous thrombotic events, and subsequently, switched her treatment plan to a different anticoagulant.

Comments

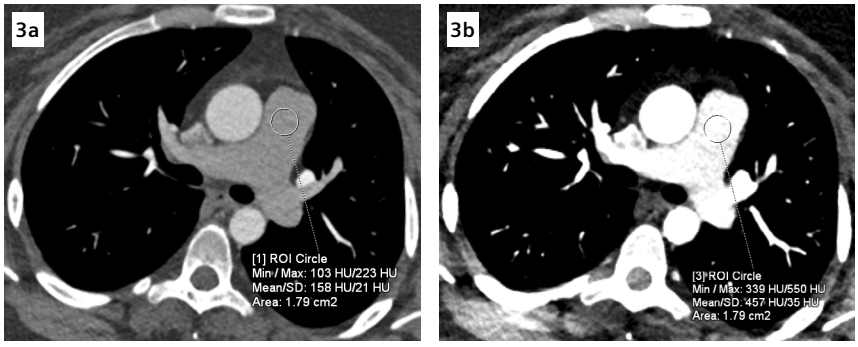
PFO is a communication between the right and left atria which fails to close postpartum. It has a high incidence in the general population, existing approximately in one-third of the adults. [1] Most people with a PFO remain asymptomatic and do not require any treatment. [2] However, the presence of a PFO may facilitate a paradoxical thromboembolus to transit from the venous to the systemic circulation and cause a systemic embolization, such as the cryptogenic stroke which this patient had suffered. In a CT chest examination, a reversal blood flow (right-to-left shunt) can also occur when the patient takes a deep breath and holds it while executing a Valsalva maneuver. As a consequence, the contrast is directed from the right atrium to the left atrium, although a "jet sign" may not be present, leading to a poor opacification of pulmonary arteries and a good opacification of the aorta, such as in this case. This may potentially limit the diagnosis of PE requiring repeated scans with re-administration of contrast material.

This case is performed on a NAEOTOM Alpha, a newly developed Dual Source CT scanner with photon-counting detectors (QuantaMax™), providing energy-resolved CT data without electronic noise. [3] One of the key benefits of photon-counting CT (PCCT) is the availability of spectral CT data in any scan, allowing for an easy switch of the image display at different monoenergetic keV settings. By displaying the images at a lower keV setting, an acquisition which missed the contrast bolus due to the opening of a PFO can be salvaged. It is also worth noting that the overall image quality in this investigation achieved an optimal level despite the patient morphotype – obesity is usually associated with image graininess due to noise, hampering precise analysis of pulmonary arterial sections, especially in the distal divisions. The reduction of image noise is particularly enhanced by

1 The segmental artery of the right upper lobe (RA1), previously obstructed and dilated at the time of acute PE (Fig. 1a, arrow), is poorly perfused in images displayed at 70 keV and shows severe retraction (Figs. 1b and 1c, arrows), confirming focal chronic PE.



2 A clot previously shown in the lateral segmental artery of the right lower lobe (RA9) (Fig. 2a, arrow) is persistently seen in an image displayed at 70 keV (Fig. 2b, arrow).



3 The poor opacification of 158 HU in the pulmonary trunk in the image displayed at 70 keV (Fig. 3a) is restored to a diagnostic level of 457 HU in the image displayed at 40 keV (Fig. 3b).

the absence of electronic noise which is dominant at low X-ray flux at the detector, such as in the case of a bariatric CT scan. Additionally, a model based iterative reconstruction approach – Quantum Iterative Reconstruction (QIR) – is also applied in the image reconstruction process, contributing to further image noise reduction.

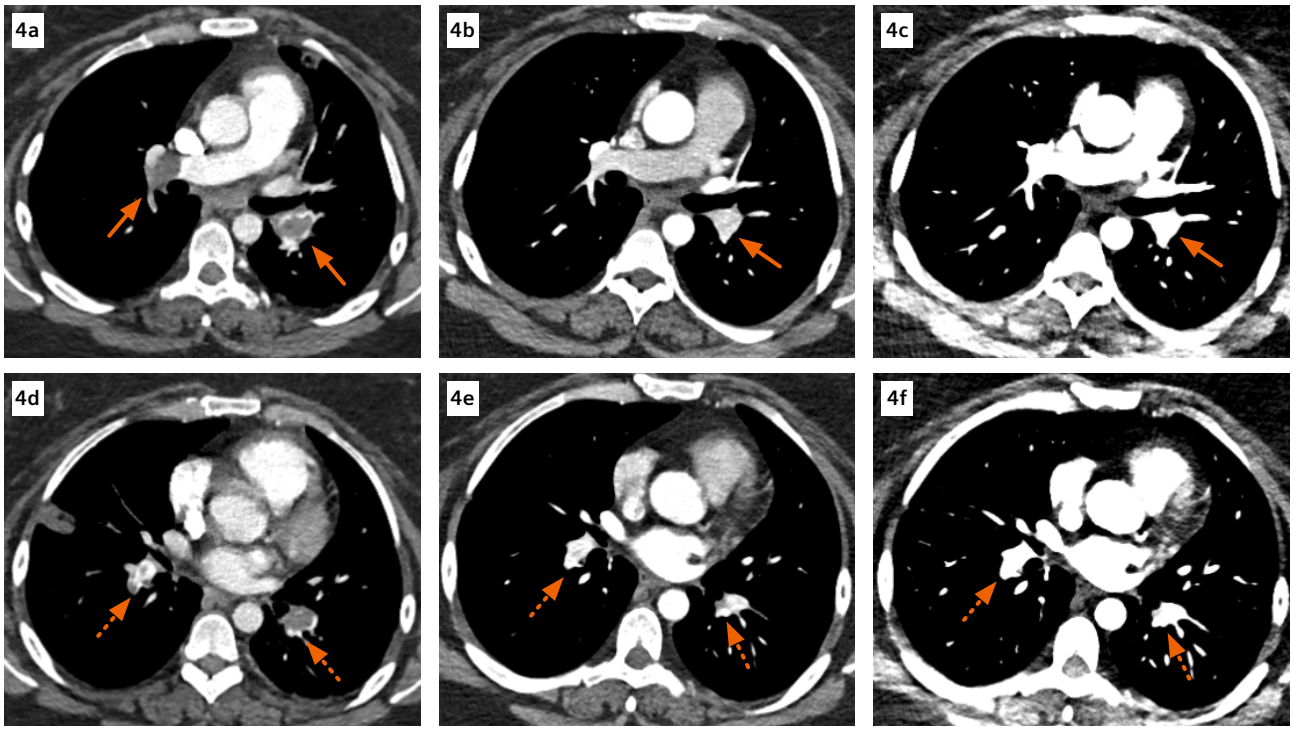
As shown in this case, the availability of spectral CT data provided by Quantum Technology plays an important role in clinical routine. In an obese patient with an unknown PFO, the use of low-energy images enables the physicians to restore the diagnostic image quality and perform a complete analysis of pulmonary arteries, without having to repeat the scan and re-administer contrast material. CT findings allow the physician to explain the worsening of the patient's situation and to consider changing the treatment plan. ●

References

[1] Joel P Giblett, et al. Patent Foramen Ovale Closure: State of the Art. Interventional Cardiology Review 2020;15:e15.

[2] Ahmed R Gonnah, et al. Patent foramen ovale: diagnostic evaluation and the role of device closure. Clinical Medicine 2022 Vol 22, No 5: 441–8.

[3] Thomas Flohr, et al. Photon-counting CT review. Physica Medica 79 (2020) 126–136.



4 **Previous acute PE (Figs. 4a & 4d) are shown in bilateral interlobar PA (arrows) and bilateral basal trunks (dotted arrows). Images displayed at 70 keV (Figs. 4b and 4e) show slightly heterogenous opacification and raise the concern about persistent clots. This is ruled out in the images displayed at 40 keV (Figs. 4c and 4f).**

Examination Protocol

Scanner	NAEOTOM Alpha
Scan area	Thorax
Scan mode	QuantumPlus
Scan length	280 mm
Scan direction	Caudo-cranial
Scan time	0.8 s
Tube voltage	120 kV
Effective mAs	134 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	10.4 mGy
DLP	356 mGy*cm
Rotation time	0.25 s
Pitch	1.5
Slice collimation	144 x 0.4 mm
Slice width	1.0 mm
Reconstruction increment	1.0 mm
Reconstruction kernel	Br36 / BI60
Spectral reconstruction	Mono +

Contrast	400 mg/mL
Volume	60 mL + 40 mL saline
Flow rate	3 mL/s
Start delay	Bolus tracking triggered at 150 HU in the ascending aorta + 3 s

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