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36.1 Introduction

Postmortem radiology has experienced a recent surge of interest in the last decade, primarily from those engaged in forensic pathology. The technology most frequently applied is postmortem computed tomography (PMCT). Technologies and ideas have been emerging ever since, aiming at overcoming PMCT's principal drawbacks: low soft tissue contrast

and lack of vascular visualization. These efforts are likely to continue, and promising approaches are at hand.

Conveniently, in the domain of postmortem imaging, most developments are triggered and fueled by developments in clinical imaging. The challenge lies in determining how to optimally apply the possibilities of modern imaging modalities to forensic and pathologic questions.

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36.2 Postmortem Computed Tomography

With PMCT angiography (PMCTA), a means of visualizing vascular and soft tissue lesions postmortem is available. The method can be expected to become more refined and adapted to special cases in the near future. A more widespread use of the method would also decrease costs, which today discourage many institutes from performing PMCTA.

Another aspect of PMCT may be material differentiation using dual-energy computed tomography (CT), a technology

that is already routinely clinically applied in many larger radiologic centers. This technique is mostly used for material differentiation or metal artefact reduction (Fig. 36.1) [1, 2], but few studies have been performed successfully applying this technique to forensic questions [3, 4].

Iterative methods for CT image reconstruction are another area of recent advances in clinical CT [5]; however, the main goal of improved image reconstruction is an increase in image quality at low radiation doses [6], a focus that is less important in postmortem imaging.

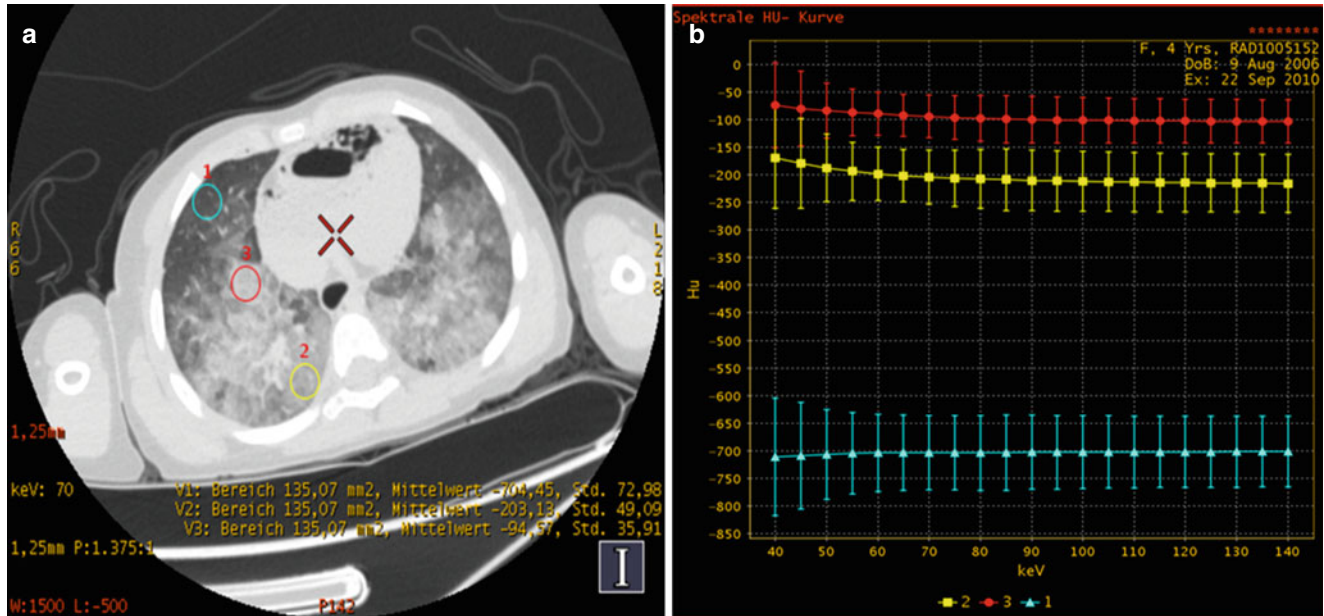


Fig. 36.1 Axial reconstruction of thoracic PMCT. (a) The image was acquired on a fast kV-switching dual-energy CT (CT 750HD, GE Healthcare, Chalfont St Giles, UK), reconstructed at virtual monochromatic 70 keV, roughly corresponding to a single-energy image acquired at 120 kVp tube voltage. Three regions of interest (ROIs) are drawn in

different areas of the left lung. (b) The corresponding spectral curves of the respective ROIs, displaying their average density in Hounsfield units (HUs) over a photon energy range from 40 to 140 keV. This curve is characteristic for many materials and ideally enables material differentiation

36.3 Postmortem Magnetic Resonance Imaging (PMMRI)

Because of its superior soft tissue contrast, postmortem PMMRI holds promise for overcoming the main drawbacks of PMCT [7, 8]. Use of a contrast agent may not be necessary for PMMRI to reveal soft tissue lesions. For vascular diagnoses, PMMRI seems less suited simply because visualization of the vascular system after contrast agent injection is not expected to be superior to PMCTA, and costs are much higher. An exception may be the use of PMMRI for cardiac

imaging because of the possibility of visualizing the myocardium and the coronary arteries during one single examination. First attempts to investigate cardiac death with PMMRI angiography have already been made [9]. Those experiences suggest promising possibilities for combining multiphase postmortem CT angiography with PMMRI (Fig. 36.2). Because of high cost and low availability, it seems likely that for the near future PMMRI will be applied only to specific cases, but the number of potential PMMRI indications is likely to grow with more research in this field.

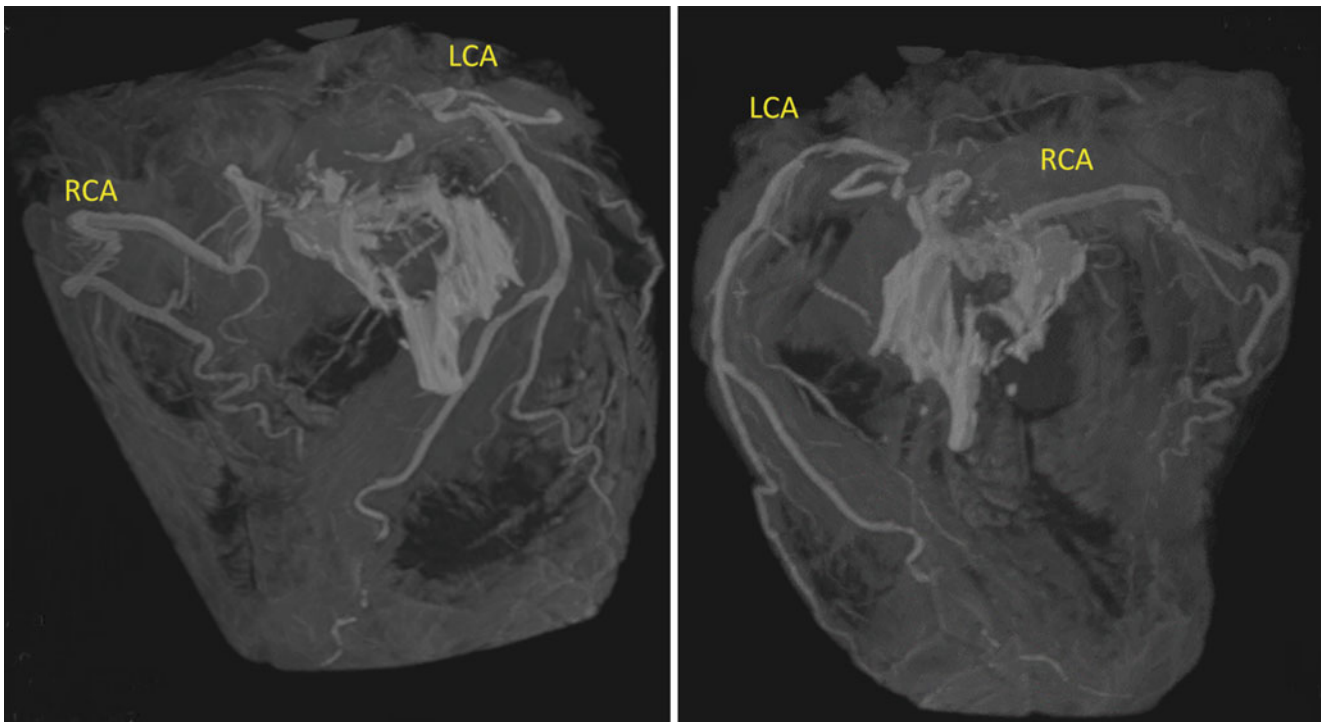


Fig. 36.2 Three-dimensional reconstructions of a PMMRI coronary angiography of an isolated heart into which Angiofil mixed with paraffin oil was injected as a contrast medium. The obtained images show

clearly visible and artefact-free visualizations of the coronary arteries (*LCA* left coronary artery, *RCA* right coronary artery)

36.4 Other Postmortem Imaging Methods

36.4.1 Three-Dimensional Surface Scanning

In forensic institutes, the application of 3D surface scanning can be of interest and has been performed for some time [10]. Many surface scanners are mobile (Fig. 36.3a) and can be applied on the scene in crimes or accidents, thus facilitating

the reconstruction of events. Objects of virtually any size can be digitized with high spatial resolution (Fig. 36.3b). Drawbacks include the cost and low availability of trained personnel. Concerning the scanning of bodies, it will be interesting to see the results of studies comparing CT 3D surface reconstruction with dedicated 3D surface scanning to better judge which of these methods is better suited for which indication.

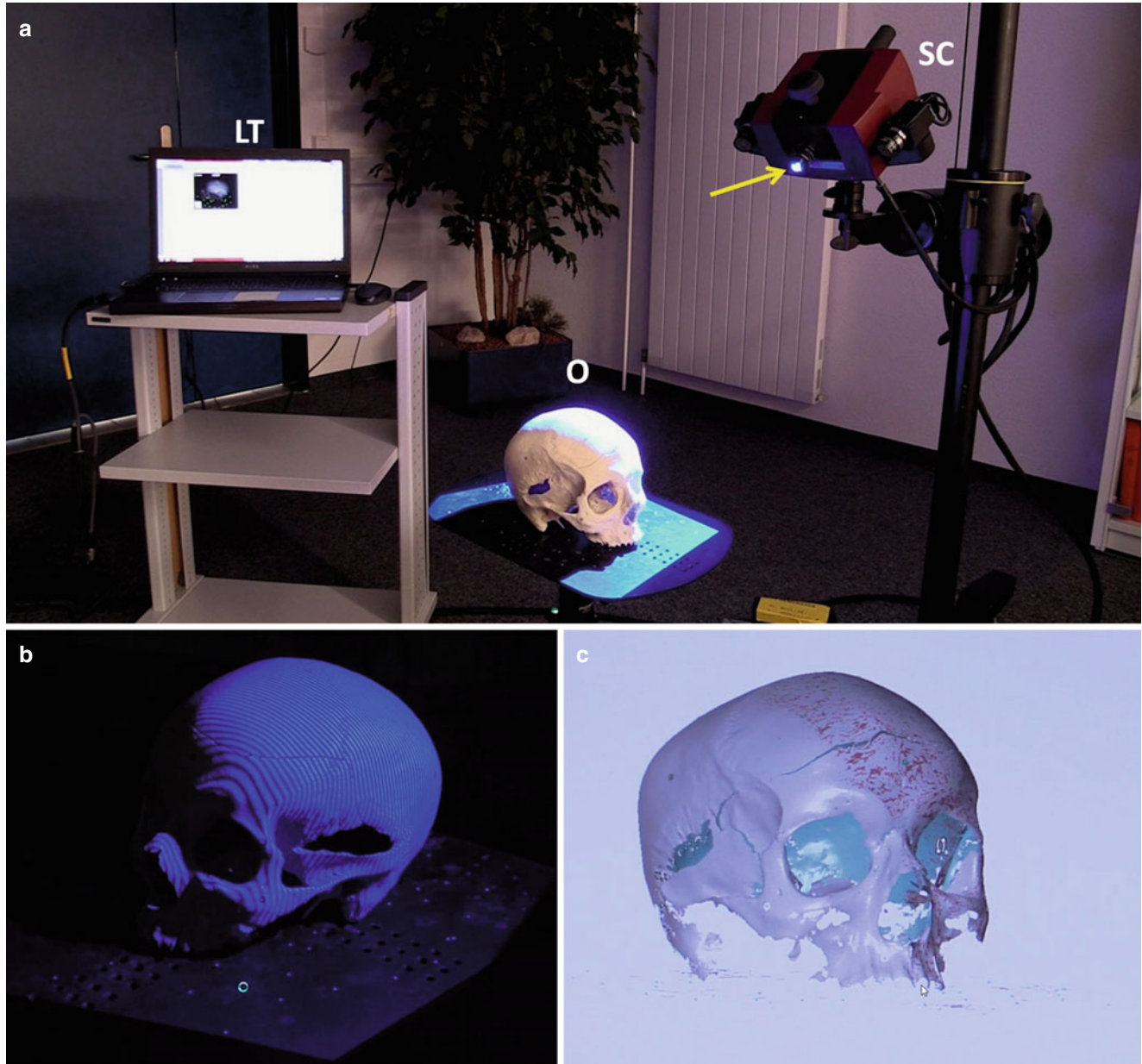


Fig. 36.3 Three-dimensional surface scanning: by using a 3D fringe light scanner, digital 3D models of different objects can be acquired. The surface scanner (SC) has a projector (arrow) emitting fringe light on the object (O) to be digitalized (in this case a skull). The scanned region automatically appears on the laptop (LT) connected to the scan-

ner, which allows the fusion of different scans to connect them together as one 3D model. The image on the lower left shows the fringe light projected onto the skull. The image on the lower right shows the partially completed 3D model (right side of the skull completed, left side with missing points, brown spots)

36.4.1.1 Ultrasound

Ultrasound has, to our knowledge, not been applied postmortem to solve forensic questions. Advantages of the technique include relatively low cost and good spatial resolution in superficial regions. A disadvantage is the limited reproducibility of the ultrasound examination because of a high influence of user experience; this is a major difficulty for large-scale evaluation of the technique in forensic settings. Another drawback is the sensitivity of ultrasound to gas

(lungs, intestine, putrefaction) and high-density gradients (e.g., bone surface). A potential application of postmortem ultrasound may be to cannulate vessels for blood sampling or contrast agent injection, as has been proposed by Jolibert [11]. By replacing the open cannulation of the femoral vessels with an ultrasound-guided puncture (Fig. 36.4), postmortem angiography will be less invasive and easier to accept even for those whose religions prohibit any incision in the body of their deceased.

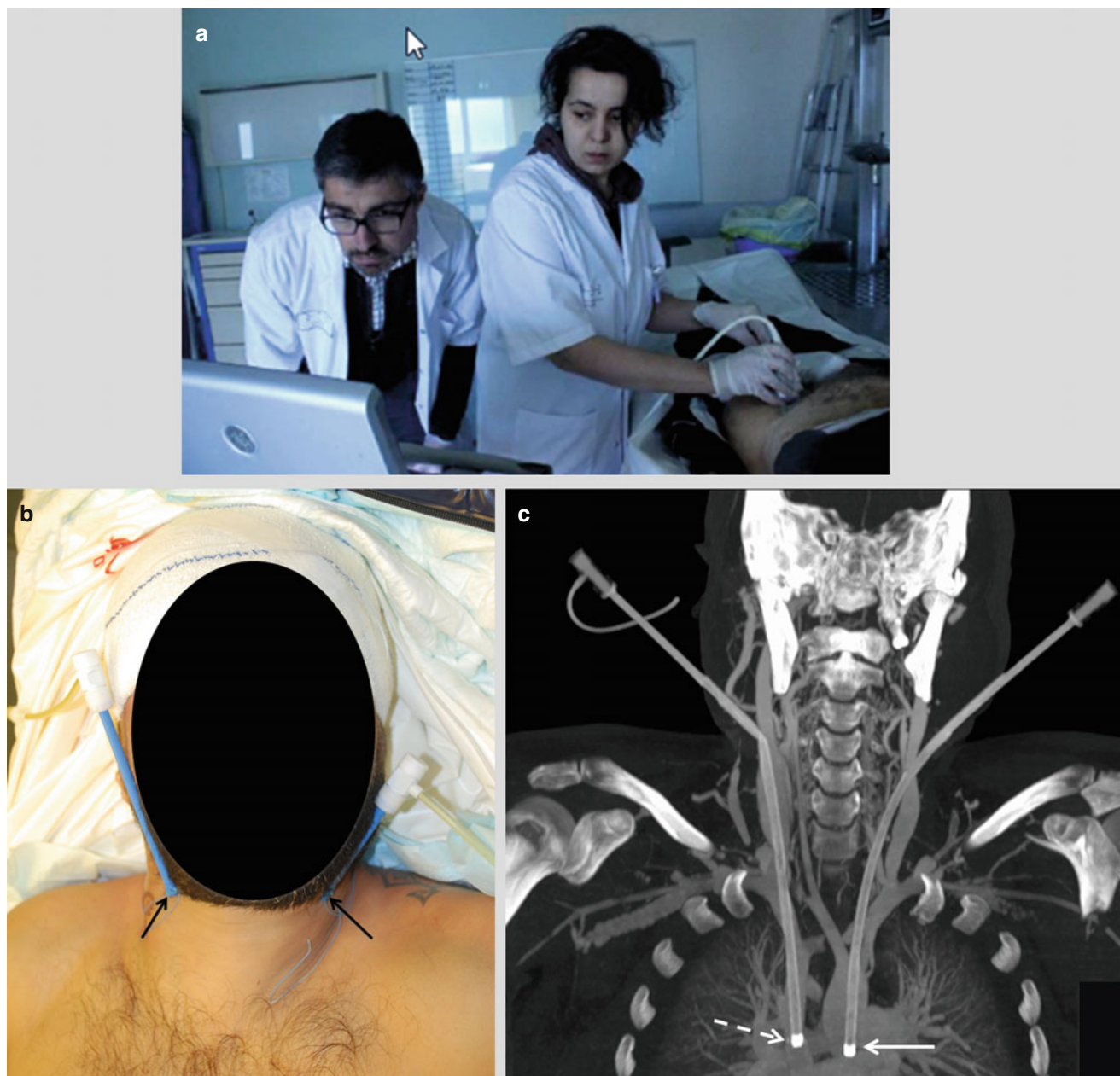


Fig. 36.4 (a) Ultrasound-guided puncture of the femoral vessels for introducing radiologic catheters (sheaths) instead of cannulation of the femoral or cervical arteries in a case in which MPMCTA is to be performed. (Photograph provided by Fabrice Dedouit, Institute of Legal Medicine, Toulouse, France.) (b) The anterior view and aspect of the cervical inserted sheaths. (c) Same case as in (b). Coronal thick maxi-

mum intensity projection (MIP) reconstruction of cervical inserted sheaths at the dynamic phase of MPMCTA. The distal extremity of the left sheath inserted in the carotid artery arrives at the aortic arch (*white arrow*), while the right sheath inserted into the jugular vein arrives at the superior vena cava (*white dotted arrow*)

Conclusion

In conclusion, postmortem imaging follows developments in clinical imaging. The challenge is to determine the optimal application of clinical imaging techniques to forensic questions. Because development and improvement of clinical imaging modalities will continue, potential postmortem applications will equally increase, and an exciting evolution of the field can be expected.

References

- Huang JY, Kerns JR, Nute JL, Liu X, Balter PA, Stingo FC, et al. An evaluation of three commercially available metal artifact reduction methods for CT imaging. *Phys Med Biol*. 2015;60:1047–67.
- Krasnicki T, Podgorski P, Guzinski M, Czarnecka A, Tupikowski K, Garcarek J, et al. Novel clinical applications of dual energy computed tomography. *Adv Clin Exp Med*. 2012;21:831–41.
- Grimm J, Wudy R, Ziegeler E, Wirth S, Uhl M, Reiser MF, Scherr M. Differentiation of heroin and cocaine using dual-energy CT—an experimental study. *Int J Legal Med*. 2014;128:475–82.
- Ruder TD, Thali Y, Bolliger SA, Somaini-Mathier S, Thali MJ, Hatch GM, Schindera ST. Material differentiation in forensic radiology with single-source dual-energy computed tomography. *Forensic Sci Med Pathol*. 2013;9:163–9.
- Deak Z, Grimm JM, Treitl M, Geyer LL, Linsenmaier U, Korner M, et al. Filtered back projection, adaptive statistical iterative reconstruction, and a model-based iterative reconstruction in abdominal CT: an experimental clinical study. *Radiology*. 2013;266:197–206.
- Naoum C, Blanke P, Leipsic J. Iterative reconstruction in cardiac CT. *J Cardiovasc Comput Tomogr*. 2015;9:255–63.
- Zech WD, Schwendener N, Persson A, Warntjes MJ, Jackowski C. Postmortem MR quantification of the heart for characterization and differentiation of ischaemic myocardial lesions. *Eur Radiol*. 2015;25:2067–73.
- Jackowski C, Schwendener N, Grabherr S, Persson A. Postmortem cardiac 3-T magnetic resonance imaging: visualization of sudden cardiac death? *J Am Coll Cardiol*. 2013;62:617–29.
- Bruguier C, Egger C, Vallée JP, Grimm J, Boulanger X, Jackowski C, et al. Postmortem magnetic resonance imaging of the heart ex situ: development of technical protocols. *Int J Legal Med*. 2015;129:559–67.
- Thali MJ, Braun M, Buck U, Aghayev E, Jackowski C, Vock P, et al. VIRTOPSY—scientific documentation, reconstruction and animation in forensic individual and real 3D data based geometric approach including optical body/object surface and radiological CT/MRI scanning. *J Forensic Sci*. 2005;50:428–42.
- Jolibert M, Cohen F, Bartoli C, Boval C, Vidal V, Gaubert JY, et al. Postmortem CT-angiography: feasibility of US-guided vascular access. *J Radiol*. 2011;92:446–9.