**Introduction**

During the last decade post-mortem imaging has strengthened its position giving the opportunity for a revival of medico-legal autopsy examination. The milestones of this examination technique were set up by publications about Virtopsy® [1] as well as the second edition of Brogdon’s forensic radiology [2]. Conventional autopsy replacement ideas seem to be restricted to compatibility between conventional and modern methods of examination heading to opportunities for higher level of objectivity [3]. Due to relatively good availability and moderate costs, the most popular technology applied in modern post-mortem imaging is post-mortem computed tomography (PMCT); however, unenhanced PMCT in violent and natural death cases may be insufficient similarly to conventional autopsy techniques in showing the actual source of bleeding related to the damage of blood vessels and even worse referring to evaluation of internal organ injuries. The addition of contrast agent (CA) administration provides the opportunity for successful supplementation of this examination technique into PMCT angiography (PMCTA).

**Material and methods**

In everyday practice of the authors’ Department of Forensic Medicine, PMCT acquisitions are performed in almost every case directed to the department. With respect to the PMCTA, we implemented two main indications for this examination: victims of potential homicide especially due to sharp force trauma and cases screened by the PMCT with positive findings showing high possibility of internal bleeding. As a member of the Technical Working Group Postmortem Angiography Methods (TWGPAM) [4] our Department took part in the multicenter study which included mostly violent death cases, referring to sharp force trauma and gunfire injuries; however, other cases with the potential interesting
A 41-year-old male presenting with complaints of pain in the chest and the back, who had been examined two times (day by day) in hospital, finally discharged home where he died the next day. Post-mortem examination revealed the ruptured dissecting aortic aneurysm, spreading to carotid and iliac arteries, with two areas of rupture in the immediate vicinity of the base of the heart and the aortic arch: a thin axial plane of the thorax based on unenhanced PMCT showing blood inside the pericardial sac, b VRT reconstruction based on PMCT at the arterial phase showing CA inside both lumens of the dissecting aortic aneurysm as well as CA extravasation into the pericardial sac, right posterior view, c the autopsy specimen showing internal wall of the aortic arch with the rupture and d microscopic specimen, showing dissection of the aortic wall with bleeding (H&E × 40).
in violent and natural death cases, there are other changes referring to blood vessel pathology taken into consideration, including diagnosis of pulmonary embolism [10], coronary thrombosis, and different aspects of coronary artery disease [11–13] including the possibility of myocardial changes visible after CA administration. Vascular changes at different locations [14] and due to specific illnesses [15] were reported. The use of PMCTA, at first aimed only at examination of bodies of deceased adults, has been introduced for other cases, even with problematic technical issues [16]. There are also reports referring to evaluation and visualization in cases after medical interventions related to the heart and great vessels [17, 18]. The publications are aimed not only at diagnostic efficiency but also present different methods of CA administration [10, 19, 20] with the propositions of standardized protocols [4, 21]. As we understand that there are no universal “remedies” for evaluation of all cases, the advances and limitations in the development of examination methods with the use of administration of CA to cadavers were discussed [22, 23]. A valuable achievement is that the presentation of cases referring to post-mortem imaging results are reaching scientific journals not only dedicated to forensic pathologists/radiologists, but also clinical disciplines [24], which may give the opportunity for better understanding of the value of post-mortem diagnosis for evaluation of clinical problems. Recent publications provide evidence that PMCTA may give forensic post-mortem examination additional strength [4]. Based on the cases presented in the current paper we may even claim that the PMCTA in selected cases might be the sufficient way of examination while combined with conventional external examination and toxicological sampling (investigation); however, in investigations of alleged medical malpractice cases, histopathological examination of specimens seems to be necessary. There are no doubts that post-mortem imaging differs from clinical examination. As we consider the history and the output of clinical imaging methods, there are plenty of challenges awaiting in the field of post-mortem imaging.

Keywords
Post-mortem examination · PMCTA · Aneurysm rupture · Cardiac rupture · Visualization

Postmortale Bildgebung bei plötzlichen Todesfällen aufgrund arterieller oder kardialer Blutungen

Zusammenfassung
Die Autoren präsentieren natürliche Todesfälle aufgrund arterieller oder kardialer Blutungen, die sowohl durch eine konventionelle Autopsie als auch mittels postmortaler Bildgebung, einschließlich postmortaler Computertomographie-Angiographie (PMCTA), beurteilt wurden. Die CT-basierte Visualisierung wird vorgestellt, in Kombination mit den Ergebnissen makroskopischer und mikroskopischer Untersuchungen. Anhand der vorgestellten Fälle wird deutlich, dass die PMCTA in selektierten Fällen als Untersuchungsverfahren ausreichend sein kann, wenn sie mit der konventionellen externen Untersuchung und der toxikologischen Erhebung kombiniert wird; jedoch scheint bei der Untersuchung von Fällen, in denen angeblich ein ärztlicher Behandlungsfehler vorliegt, die histopathologische Untersuchung von Proben notwendig zu sein. Es besteht kein Zweifel, dass sich die postmortale Bildgebung von der klinischen Untersuchung unterscheidet. Betrachtet man die Entwicklung und die Ergebnisse der klinischen Bildungsverfahren, so wird es zahlreiche Herausforderungen im Bereich der postmortalen Bildgebung geben.

Schlüsselwörter
Postmortale Untersuchung · PMCTA · Aneurysmaruptur · Herzeruptur · Visualisierung
A 55-year-old woman with a history of hypertensive and Graves-Basedow diseases, under systematic medical supervision, collapsed and died unexpectedly. Post-mortem examination revealed widening of the circumference of the ascending aorta (up to 10 cm), the ruptured dissecting aortic aneurysm with two ruptures of the ascending aorta, both diameters approximately 1 cm: a thick axial plane of the thorax based on unenhanced PMCT showing blood inside the pericardial sac, b thin axial plane based on PMCTA at the arterial phase showing dissecting aortic aneurysm, c VRT reconstruction based on PMCTA at the arterial phase showing CA inside both lumens of the dissected aortic aneurysm as well as CA extravasation to the pericardial sac, left anterior view and d autopsy specimen showing dissecting aneurysm of the descending aorta.

A 75-year-old male suffered from pain in the inguinal area and subsequently lower back pain. He had been observed for several hours in hospital and discharged home, where he died on the same day: a thin axial plane of the abdomen based on unenhanced PMCT showing the changes located anteriorly to the spine and at the right side (suggesting bleeding because of ruptured aneurysm), b thin coronal plane based on PMCTA at the arterial phase showing ruptured aneurysm of abdominal aorta with CA extravasation to the right, note the cannulation of femoral vessels at the right side and c VRT reconstruction of the aneurysm based on PMCTA at the arterial phase, showing the leakage (arrow).
A 56-year-old male without previous treatment died unexpectedly in the street. Forensic autopsy revealed areas of myocardial necrosis (pale red, partially yellowish tinted) of 9 × 3 cm in size, with the double rupture of the posterior wall (each about 1 cm) of the left ventricle at the apical region: a) axial plane of the thorax based on unenhanced PMCT showing blood inside the pericardial sac, b), c) both based on PMCTA at the arterial phase: thin axial (b) and coronal (c) plane showing CA leakage to the pericardial sac (arrow), d) the autopsy specimen showing the apical part of the heart with the rupture (encircled), e) the autopsy specimen with the cut in the left ventricle, showing the area of necrosis and rupture (arrow) and f) microscopic specimen, showing different stages of necrosis of cardiomyocytes (H&E × 40).

Compliance with ethical guidelines

Conflict of interests. K. J. Woźniak, A. Moskala, E. Rzepecka-Woźniak, P. Kluza, K. Romaszko and O. Lopatin declare that they have no competing interests.

All studies described in this article were carried out in accordance with national law and the Helsinki Declaration from 1964 (in its current revised form). The PMCTA research was approved by the appropriate University Bioethics Committee (KBET/225/B/2012).

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Lesetipp

Klinische Obduktionen

Nach Vorgaben des Krankenhaus strukturgesetzes soll die Auszahlung finanzieller Zuschläge für klinische Obduktionen im Krankenhaus an das Erreichen einer bestimmten Quote geknüpft werden. Ziel dieser Maßnahme ist die Erhöhung der Häufigkeit klinischer Obduktionen in deutschen Krankenhäusern, damit die Möglichkeit erhalten bleibt, die dabei gewonnenen Erkenntnisse für die Aus- und Weiterbildung des klinischen Personals zu nutzen, ggf. aus Fehlern zu lernen und Obduktionen als Qualitätssicherungsinstrument einzusetzen.