Human Pathology (2014) **45**, 1813–1823

ELSEVIER

Human PATHOLOGY

www.elsevier.com/locate/humpath

Original contribution

Contrast-enhanced postmortem computed tomography in clinical pathology: enhanced value of 20 clinical autopsies☆

Saskia E. Westphal MD[a,*,1], Jonas C. Apitzsch MD[b,c,1], Tobias Penzkofer MD[b,d], Christiane K. Kuhl MD[b], Andreas H. Mahnken MD, MBA[b,c], Ruth Knüchel MD[a]

[a]*Department of Pathology, RWTH Aachen University Hospital, Aachen, Germany*
[b]*Department of Diagnostic and Interventional Radiology, RWTH Aachen University Hospital, Aachen, Germany*
[c]*Department of Diagnostic and Interventional Radiology, University Hospital, Philipps-University Marburg, Marburg, Germany*
[d]*Surgical Planning Laboratory, Department of Radiology, Brigham and Women's Hospital, Boston, MA*

Received 15 February 2014; revised 20 May 2014; accepted 21 May 2014

Keywords:
Virtual autopsy;
PMCT;
PMCTA;
Postmortem angiography;
Necropsy

Summary Postmortem computed tomography (PMCT) is a modern tool that complements autopsy diagnostics. In clinical autopsies, a major cause of death is cardiovascular disease. To improve the performance of PMCT in cardiovascular disease, full body angiography was developed (PMCT angiography [PMCTA]). Twenty PMCTA scans generated before autopsy were compared with native PMCT and clinical autopsy. The objective of the study was to quantify the additional diagnostic value of adding angiography to native imaging and to compare PMCT and PMCTA findings to autopsy findings. The diagnosis of the cause of death was identical or overlapped in 80% of the cases that used PMCTA and 70% that used PMCT. The additional diagnostic yield given by PMCT and PMCTA in combination with autopsy was 55%. PMCT yielded additional diagnoses in the musculoskeletal system. The greatest additional diagnostic value of PMCTA was in association with cardiovascular diagnoses. The accuracy of PMCTA for cardiac causes of death was 80%, and the positive predictive value was 90%. The findings indicate that native PMCT cannot display the cardiovascular system sufficiently clearly for high-quality diagnostic assessment. However, PMCTA is a powerful tool in autopsy cases with a history of cardiovascular disease and/or a suspected cardiovascular cause of death. The combination of PMCTA and clinical autopsy enhances diagnostic quality and completeness of the autopsy report. Furthermore, in cases without consent or with a restricted consent for clinical autopsy, PMCTA has the potential to provide information on cardiovascular causes of death.

1. Introduction

Autopsies serve variable purposes for clinicians, hospital management, pathologists, and students, including quality control, re-evaluation of therapeutic and diagnostic strategies, resident training, and student teaching. In the United States,

☆ Disclosures: The authors declare that they have nothing to disclose/no conflict of interest.

* Corresponding author. Institute of Pathology, Uniklinikum Aachen, Pauwelsstr 30, 52074 Aachen, Germany.
E-mail address: swestphal@ukaachen.de (S. E. Westphal).

[1] Both authors contributed equally to this work.

http://dx.doi.org/10.1016/j.humpath.2014.05.007
0046-8177/

Australia, Asia, and Europe, autopsy rates are declining [1-4]. It is therefore more important than ever for pathologists to extract as much information as possible from every autopsy case. Recently, new imaging methods have opened new horizons for postmortem examinations.

In recent years, radiologic imaging techniques have been introduced to postmortem diagnostics. In clinical pathology, unenhanced postmortem computed tomography (PMCT) imaging has been studied as a supplement to classic autopsy. A limitation of native PMCT is the lack of discrimination among cardiovascular pathologies, including noncalcified vascular occlusions and myocardial infarction [5,6]. Because of the high prevalence of cardiovascular disease in the Western population and high rates of cardiovascular mortality, sudden cardiac deaths in the community have been studied with PMCT angiography (PMCTA) [7,8]. Little attention has been paid to inhospital deaths from cardiovascular disease, as is often encountered in routine clinical autopsies. Therefore, a postmortem full-body computed tomography angiography routine was established (PMCTA), and the results were compared with the results of both native PMCT and conventional autopsy. Diagnoses were classified according to the *International Statistical Classification of Diseases*, *10th Revision* (*ICD-10*), as published by the World Health Organization [9].

Results were compared with regard to the following:

1. Cause of death,
2. Death-related diagnoses,
3. Reconstruction of the pathogenetic mechanisms,
4. Nonspecific findings (postmortem changes, changes related to cardiopulmonary resuscitation [CPR]), and
5. Secondary diagnoses.

2. Materials and methods

This study was conducted at a German university hospital after approval by the local ethics committee had been obtained (EK 051/11).

Twenty deceased patients who underwent clinical autopsies in the department of pathology were included in the study. In all cases, consent for imaging and autopsy was obtained. The study cohort included 12 male and 8 female patients with a mean age of 63.2 years, ranging from 22 to 85.4 years. The cases consisted of 3 deaths on a standard hospital ward and 17 deaths in an intensive care unit. The combination of imaging and classic autopsy was used whenever computed tomography (CT) was available before classic autopsies. Thus, cases were selected randomly.

2.1. PMCT angiography

At a mean time of 39 (±25) hours after death, the body was wrapped (arms up) in an artifact-free body bag in the supine position. One 11-Fr sheath introducer (Radifocus Introducer II; Terumo Europe, Leuven, Belgium) was introduced in each common femoral artery using the Seldinger technique. A water-based contrast medium prepared from methyl cellulose and a barium sulfate–based contrast agent (Micropaque; Guerbet GmbH, Sulzbach, Germany) or an iodine-based contrast agent (Solutrast 300; Bracco Imaging Deutschland GmbH, Konstanz, Germany) was calibrated to a density of 300 Hounsfield units. After a larynx mask (Ambu AuraOnce; Ambu A/S, Ballerup, Denmark) was placed, the lungs were inflated with air. Then, the tube was sealed and fixed in place.

The body was placed in the CT gantry and scanned from head to toe with a 64 dual-source CT scanner (SOMATOM Definition; Siemens, Forchheim, Germany). A tube voltage of 120 kV with variable mAs and 5.0, 1.0, and 0.75 mm collimation, a pitch of 0.65, and a rotation time of 0.33 seconds was applied. From the raw data, axial images with 5- and 1-mm-slice thicknesses and a reconstruction increment of 4 or 0.7 mm were reconstructed using medium smooth (B20) and sharp (B50 and B70) convolution kernels. Next, contrast medium was injected by hand with a 20-mL syringe supported by a peristaltic pump. When contrast medium left the contralateral arterial sheath introducer, injection of contrast medium was stopped. Again, a full-body scan was performed. Including preparation of the femoral vessels and introduction of catheters, the average duration of the procedure was 180 ± 30 minutes. After reconstruction of the raw data, the reconstructed images were transferred to a PACS (picture archiving and communication system; iSite Radiology; Philips Medical Systems, Best, Netherlands). The CT scanner was used outside regular work hours (ie, before 7:30 AM or after 6:00 PM).

Afterwards, the pictures were evaluated by 2 experienced general radiologists with previous experience in native postmortem imaging. The autopsy request form with clinical information was provided to the radiologists before image interpretation. The radiologists reported their findings in a standardized form, including the neurocranium, thorax, abdomen, and extremities. Arterial and venous contrasts were achieved in 7 cases. In 11 cases, only arterial contrast enhancement was achieved, and in 2 cases, only venous filling was accomplished.

2.2. Conventional autopsy

The autopsy was performed in a standardized manner (accredited department of pathology, IS0/IEC 17020) by experienced pathologists at a mean time of 53 (±25) hours after death. All 3 body cavities (neurocranium, thorax, and abdomen) were opened according to standard autopsy protocols. In 6 cases, no consent for brain autopsy was given. After complete autopsy, findings were demonstrated to clinical colleagues who had requested the autopsy. In the context of an interdisciplinary team meeting, the clinical picture of the patient's admission, hospitalization, and clinical course before death was correlated with the autopsy findings. Therapeutic and diagnostic strategies were discussed.