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Detection of coronary thrombosis after multi-phase postmortem CT-angiography

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ABSTRACT

The aim of this study was to compare postmortem angiography-based, autopsy-based and histology-based diagnoses of acute coronary thrombosis in a series of medicolegal cases that underwent postmortem angiographies according to multiphase CT-angiography protocol. Our study included 150 medicolegal cases. All cases underwent native CT-scan, postmortem angiography, complete conventional autopsy and histological examination of the main organs and coronary arteries. In 10 out of the 150 investigated cases, postmortem angiographies revealed coronary arterial luminal filling defects and the absence of collateral vessels, suggesting acute coronary thromboses. Radiological findings were confirmed by autopsy and histological examinations in all cases. In 40 out of 150 cases, angiograms revealed complete or incomplete coronary arterial luminal filling defects and the presence of collateral vessels. Histological examinations did not reveal free-floating or non-adherent thrombi in the coronary arteries in any of these cases. Though postmortem angiography examination has not been well-established for the diagnosis of acute coronary thrombosis, luminal filling defects in coronary arteries suggesting acute thromboses can be observed through angiography and subsequently confirmed by autopsy and histological examinations.

1. Introduction

Recent developments in postmortem imaging have led to an implementation of postmortem computed tomography (CT) and postmortem magnetic resonance imaging (MRI) for the benefit of forensic pathology investigations. Several studies published over the past 10 years have shown that by combining autopsy techniques and cross-sectional imaging, the value of postmortem examinations for legal purposes may be significantly improved [1–13]. An increasing number of medicolegal centers are now equipped with CT and MRI systems in order to use these imaging techniques for quality improvement in the forensic field.

Despite the advantages of the Multi-Detector Computed Tomography (MDCT) in terms of performance simplicity, data acquisition and cost effectiveness, this technique has the disadvantage of limited organ parenchyma and vascular system visualization. Postmortem angiography techniques have been developed to overcome these limitations and increase the diagnostic value of MDCT [14–34].

One of the most promising fields of research in postmortem angiography is represented by targeted coronary angiography [28–30,34]. Interesting methods of postmortem CT coronary angiography using minimally invasive approaches have been proposed by Saunders et al. [28] and Roberts et al. [29] showing that coronary artery diseases can be diagnosed through postmortem CT coronary angiography. Grabherr et al. [26] proposed a technique of whole-body CT-angiography, called the Multi-Phase Postmortem CT-Angiography (MPMCTA), which would allow optimal filling of the arterial and venous systems to be achieved, including coronary arteries.

Postmortem imaging is increasingly considered as an integral part of the routine autopsy process by most forensic pathologists, however few studies have compared imaging-based and autopsy-based diagnoses. Findings from a study performed on 10 cases by Roberts et al. [35], in which postmortem MRI was followed by conventional autopsies, showed important imaging weaknesses, notably an inability to detect arterial occlusions and differentiate between pulmonary edema and pneumonia. Weustink et al. [36] reported similar findings in a study performed in 2009 on a sample of 30 adult deaths. Roberts et al. [37] recently published the results of a study performed on 182 adult deaths that were reported to the coroner and underwent whole-body CT and MRI followed by conventional autopsies.

Correlations between CT angiography-based diagnoses with postmortem macroscopic and microscopic findings have yet to be presented. The results of such studies would be of utmost importance to assess the accuracy of postmortem angiography imaging in diagnosing the cause of death. Indeed, irrespective of the

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angiographic technique, perfusion liquid or contrast agent chosen, forensic pathologists have questioned certain elements of postmortem angiography in general and postmortem coronary angiography in particular, especially the dislodging of arterial thrombi due to the introduction of the contrast agent or perfusion liquid in the vascular system.

The aim of this study was to compare postmortem angiography-based, autopsy-based and coronary artery histology-based diagnoses of acute coronary artery thrombosis obtained from 150 medicolegal cases which underwent postmortem angiographies according to Grabherr's protocol [26], conventional autopsies and histological examinations of the coronary arteries. There were 10 cases in which postmortem investigations concurred in identifying coronary arterial luminal filling defects and histologically confirmed coronary thrombosis.

2. Materials and methods

2.1. Subjects

Our study included 150 medicolegal cases. The bodies were admitted to our medicolegal center by the local inquiring authorities to ascertain the cause of death and, depending on the circumstances, determine the sequence of events leading to death. All cases underwent native CT-scans, postmortem angiographies, complete conventional autopsies, as well as histological examinations of the main organs and coronary arteries. Exclusion criteria consisted of severely decomposed bodies and cases presenting severe trauma involving the major vessels of the lower limbs. Cases selected for the study included those presenting medical records, circumstances of death or native CT-scans suggesting cardiac deaths, internal or external hemorrhages as well as traumas involving the vascular system. The interval between death and postmortem angiography was 5.0–50 h (mean 28.8 h, median 29.0 h, standard deviation 12.2).

2.2. Radiological examinations

Native CT-scans from the top of the head until the small trochanters were performed on an 8-row CT-unit (CT LightSpeed 8, GE Healthcare, Milwaukee, WI, USA) using the following scan parameters: field of view (FOV): 50 cm; slice thickness: 2.5 mm; reconstruction interval: 2 mm, 120 kVp and 280 mA; rotation tube 1 s.; helical pitch 0.825; scan time 50–60 s. Postmortem angiographies were performed according to the protocol proposed by Grabherr et al. [26], using the same quantity of contrast-agent mixture as well as the same perfusion parameters. Cannulation of the femoral vessels of one side was carried out using cannulas (MAQUET Gmbh & Co. KG, Rastatt, Germany) with a 16-French diameter for arteries and 18-French for veins. A recently developed pressure-controlled perfusion device (Virtangio®, Fumedica AG, Muri, Switzerland) was used to inject a mixture of contrast agent (Angiofil®, Fumedica AG, Muri, Switzerland) with paraffin oil (paraffinum liquidum, obtained at a local pharmacy). The total amount of injected liquid per body was 3300 ml including 6% contrast agent (198 ml of Angiofil®). The arterial phase of angiography was carried out after the injection of 1200 ml (flow rate: 800 ml / min) of this mixture into one femoral artery using the following scan parameters: field of view: 50 cm; reconstructed slice thickness: 1.25 mm; interval of reconstruction: 0.6 mm, 120 kVp and 280 mA; rotation tube 1 s.; helical pitch 0.825; scan time 50–60 s. The venous phase of angiography was performed after the injection of 1600 ml (flow rate: 800 ml/min) of contrast-agent mixture into one femoral vein using the following scan parameters: field of view: 50 cm; reconstructed slice thickness: 2.5 mm; reconstruction interval: 1.2 mm, 120 kVp, and 280 mA; rotation tube 1 s; helical pitch 0.825; scan time 50–60 s. Lastly, the so-called dynamic phase was performed. In this phase, 500 ml more contrast-agent mixture was injected into the femoral artery over 2.5 min (flow rate 200 ml/min). Data acquisition using the same scan parameters as for the venous phase was performed during body perfusion. All angiographic phases covered the same areas as native CT-scans (from the top of the head until the small trochanters).

Radiological data was obtained through postmortem radiological reports performed jointly by a board-certified radiologist specialized in vascular radiology and a board-certified forensic pathologist trained in forensic imaging. Another viewing was performed by two forensic pathologists trained in forensic imaging and one radiologist specialized in vascular radiology with experience in postmortem imaging in order to verify all data indicated in the postmortem radiological reports. This second viewing of data confirmed all previous findings and did not add further diagnoses beyond the ones already stated.

2.3. Conventional autopsy and histology

External examinations were preceded by native CT scans and followed by postmortem angiographies. Conventional autopsies were performed within 1–12 h post angiography by two forensic pathologists, at least one of whom board-certified. The main epicardial coronary arteries were either serially sectioned at approximately 5 mm intervals or longitudinally sectioned intact on the heart, where segments of interest were removed and decalcified if needed before paraffin processing. Histological examinations were systematically and routinely performed on tissues obtained from the heart, lungs, kidneys, liver, brain and coronary arteries. Full thickness areas involving the left anterior, lateral free wall, posterior left and right ventricle as well as interventricular septum were sampled. Coronary arteries with thrombi were embedded serially in paraffin and divided into segments maintaining proximal-to-distal orientation. Histologic sections were prepared at three different equally spaced levels in order to best identify rupture sites. Routine histology stains for heart tissues and coronary arteries included the following colorations: hematoxylin and eosin, Masson's trichrome and Verhoeff van Gieson. Immunohistochemistry was not performed.

2.4. Role of the funding sources

The funding sources of this study had no role in the study design, data collection, data analysis, data interpretation or writing of this report.

2.5. Ethical aspects

Ethical matters were discussed with the local ethics committee. This study was authorized as a part of an investigation into medicolegal autopsies ordered by the judicial authorities.

3. Results

In 10 out of 150 cases (Table 1.) native CT-scans showed isolated or multiple calcifications involving the coronary arteries. Postmortem angiographies revealed coronary arterial luminal filling defects as well as the absence of collateral vessels, suggesting acute coronary thromboses (Figs. 1a and 2a). These findings were confirmed by autopsy (Figs. 1b and 2b) and histological examinations that showed ruptured plaques with superimposed occlusive or partially occlusive thrombosis (Figs. 1c and 2c).

In 40 out of 150 cases, native CT-scan coronary findings ranged from isolated to multiple, severe calcifications. Postmortem