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Clinical Investigation

CLINICAL INVESTIGATION

Prospective study of device-related complications in intensive care unit detected by virtual autopsy

D. Wichmann[1,*], A. Heinemann[2], S. Zähler[1], H. Vogel[2], W. Höpker[3], K. Püschel[2] and S. Kluge[1]

[1]Department of Intensive Care Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany, [2]Institute of Legal Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany and [3]Institute of Pathology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

*Corresponding author. E-mail: d.wichmann@uke.de

Abstract

Background: There has been increasing use of invasive techniques, such as extracorporeal organ support, in intensive care units (ICU), and declining autopsy rates. Thus, new measures are needed to maintain high-quality standards. We investigated the potential of computed tomography (CT)-based virtual autopsy to substitute for medical autopsy in this setting.

Methods: We investigated the potential of virtual autopsy by *post-mortem* CT to identify complications associated with medical devices in a prospective study of patients who had died in the ICU. Clinical records were reviewed to determine the number and types of medical devices used, and findings from medical and virtual autopsies, related and unrelated to the medical devices, were compared.

Results: Medical and virtual autopsies could be performed in 61 patients (Group M/V), and virtual autopsy only in 101 patients (Group V). In Group M/V, 41 device-related complications and 30 device malpositions were identified, but only with a low inter-method agreement. Major findings unrelated to a device were identified in about 25% of patients with a high level of agreement between methods. In Group V, 8 device complications and 36 device malpositions were identified.

Conclusions: Device-related complications are frequent in ICU patients. Virtual and medical autopsies showed clear differences in the detection of complications and device malpositions. Both methods should supplement each other rather than one alone for quality control of medical devices in the ICU. Further studies should focus on the identification of special patient populations in which virtual autopsy might be of particular benefit.

Clinical trial registration: NCT01541982.

Keywords: device complications; quality control; virtual autopsy; computed tomography

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Editor's key points

- Invasive devices are increasingly used in the critically ill, and information on complications relating to their use is important.
- This study compared 'virtual autopsy' by *post-mortem* computed tomography scanning with conventional medical autopsy in patients who died in the intensive care unit.
- Device-related complications or device malposition was noted in almost 50% of patients; more of these were found by medical autopsy, with poor agreement between autopsy methods.
- However, detection of malpositioned devices was greater by virtual autopsy, which could have a role in detecting device-related morbidity after death.

Use of invasive techniques and procedures, such as extracorporeal organ support in intensive care medicine, has increased in recent years and has been extended to wider patient populations.[1,2] New extracorporeal therapies are being designed to provide supportive treatment beyond the classic indications, such as renal replacement therapies.[3,4] Such patient populations are generally highly vulnerable, owing to their unstable clinical condition, and the new therapies carry a substantial risk of complications. Therefore, it should be a priority to improve quality management in this setting.

For more than a century, autopsy was the gold standard for determining the cause of death,[5] but autopsy rates have now fallen below 5% in most developed countries. Many reasons have been identified for this decline in autopsies, the most important being that physicians not asking relatives for consent to perform an autopsy, fear of litigation for missed diagnoses identified by autopsy, and financial constraints.[6–9] Thus, new methods are needed to improve quality control in one of the most vulnerable patient populations. Several studies have demonstrated that virtual autopsy by *post-mortem* computed tomography (pmCT) or *post-mortem* magnetic resonance imaging has a potential to replace the traditional medical autopsy, at least in part.[10–13] Thus, the object of this study was to compare the value of virtual autopsy by pmCT with traditional medical autopsy to detect the complications associated with the use of medical devices in the intensive care unit (ICU).

Methods

Setting and patients

The study was performed from April 1, 2011 to March 31, 2012, at the Department of Intensive Care Medicine of the University Medical Center Hamburg-Eppendorf, Germany. During this time, the department comprised 10 ICUs with 120 beds and served all specialties of adult intensive care medicine. Patients who died at the department who had previously undergone extracorporeal organ support for lung-, kidney-, heart-, or liver-replacement therapy, or who had received more than three vascular devices (e.g. dialysis catheter, central venous catheter, arterial cannula, gastric tube, or Foley catheter) were eligible for the study. In accordance with the legal requirements,[14] the relatives of every deceased patient were asked to provide informed consent for virtual and medical autopsies (Group M/V) or virtual autopsy only (Group V), and gave consent for the use of images in this paper. Part of the general job training for all physicians in our institution (n=110) is a skill training on how to communicate serious news to patients and relatives. Thus, interviews on informed consent with relatives were held by specially trained personal. For Group M/V, a multiphase pmCT angiography was also performed. The study was approved by the Ethics Committee of the Hamburg Chamber of Physicians and complied with the Declaration of Helsinki.

Virtual autopsy

Virtual autopsy was done at the Department of Legal Medicine of the University Medical Center Hamburg-Eppendorf using a Philips MX8000 4-slice CT scanner and a Philips Brilliant 16-channel CT scanner (Philips Healthcare, Best, the Netherlands). It consisted of native pmCT of the head, neck, chest, abdomen, and hip joints. If the relatives gave informed consent for a medical autopsy, an additional multiphase pmCT angiography was performed, as described previously.[10,15]

Classification of radiological findings

A board-certified radiologist with a considerable experience in reading *post-mortem* images reviewed all patients. The radiologist had access to all clinical records and death certificates, but was unaware of the findings of the medical autopsy (which was done afterwards). In patients where an angiography was performed, findings were cross-checked by a second expert. The computed tomographic data were processed using OsiriX MD version 7.5 (Pixmeo, Geneva, Switzerland). The animated videos were processed with Final Cut Pro X®, version 10.2.3 (Apple, Cupertino, CA, USA).

Device-related complications and wrongly positioned devices

A complication was defined as an organ injury (e.g. bleeding, thrombosis, or perforation) attributed to a medical device. Devices that did not cause a complication but were in the wrong position were recorded separately (e.g. a central venous catheter introduced into the internal jugular vein diverting into the subclavian vein). The analysis included only device-related findings, which were not known *pre-mortem*.

Medical autopsy and histological examination

Full medical autopsy with histology examination according to the hospital's institutional standards was done after virtual autopsy by residents from the Department of Legal Medicine and the Department of Pathology supervised by a board-certified senior pathologist. The pathologists had access to each patient's clinical records and death certificate, but were unaware of the findings from the virtual autopsy.[11]

Classification of autopsy findings

Two board-certified intensive care medicine specialists reviewed the clinical records for clinical diagnoses made before death, and compared these with the reports from the virtual and medical autopsies. If the reviewers' assessments agreed, the review process was complete. All cases with discrepant findings were cross-checked. In cases of uncertainty or disagreement, a consensus was achieved through mediation by a pathologist and a specialist in the field of interest.