



Review Article

Virtopsy complementing traditional autopsy

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ABSTRACT

Introduction: The autopsy is from the Greek word *autopsia* meaning “to see with one’s own eyes.” This procedure leads to extensive mutilation which often leaves the grieving family bothered. These drawbacks of the conventional autopsy led to the development of virtopsy. Virtopsy is the combination of the two words “Virtual Autopsy”. Virtopsy, like autopsy, is a multidisciplinary approach that uses other branches of advanced sciences like radiology, image processing, physics, and biomechanics that aid the conventional autopsy.

This review article enumerates the benefits and drawbacks of both conventional autopsy and virtopsy indicating that neither is superior over the other and both must be used together to achieve a highly acceptable procedure to conduct autopsies.

Conclusion: Virtopsy is not the alternative to conventional autopsy but can be supportive and aids in achieving the perfect balance between the modern virtual autopsy and the old conventional autopsy. This review advocates a multidisciplinary research and advocacy to develop improved tools and protocols for better symbiotic relation between virtual autopsy and conventional autopsy to get the best out of the two.

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1. Introduction

The autopsy is from the Greek word *autopsia* meaning “to see with one’s own eyes.”¹ Autopsy is the basic science of forensic medicine which deals with examination of a corpse to determine the cause and manner of death.² Autopsy consists of dissection, interpretation and cataloguing.³ The forensic experts arrive at a conclusion from the data obtained from this examination. Though this procedure is conventional it has many drawbacks. It is time consuming, leaves the individuals conducting the autopsy exposed to various pathogens. This procedure leads to extensive mutilation which often leaves the grieving family bothered. Certain religious groups such as the Jews and Muslims do not completely accept this mutilation of the body as it is against their religious beliefs.

These drawbacks of the conventional autopsy led to the development of virtopsy. Virtopsy is a minimally invasive,

observer-independent procedure that takes into account the use of various highly advanced imaging techniques and 3D construction softwares. Virtopsy is the combination of the two words “Virtual Autopsy”. The word “virtual” is derived from the Latin word *virtus* which means “useful, effectual, and good.”⁴ Virtopsy, like autopsy, is a multidisciplinary approach that uses other branches of advanced sciences like radiology, image processing, physics, and biomechanics that aid the conventional autopsy.⁵

Virtopsy represents not only the first step toward a better acquiring of information regarding death causes, lesions’ types, etc., through modern technologies but also an alternative that ensures the right to body integrity, to intimacy, and attributing an intrinsic value to the human body. At the same time, virtopsy avoids social stigma, whose huge prejudices would manifest on the family members and on the deceased person, influencing the image of his life. Although virtopsy is advanced and has many benefits, it in itself is not entirely devoid of drawbacks.

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2. History of imaging autopsy

The Virtopsy was developed by Richard Dirnhofer, former Director of Forensic Medicine, Berne. Later on, it was continued by his successor, Michel Thali and his colleagues at the University of Berne's Institute of Forensic Medicine, Switzerland. "If you are doing an autopsy, you are always destroying the 3-D geometry of the body," says Thali, the forensic pathologist and project manager for Virtopsy. "Using this cross-section imaging technique, it is possible to document the same findings in a noninvasive way."⁶ Wüllenweber et al. first reported the use of computed tomography (CT) scan for forensic inquest in the year 1977 in patients with cranial gunshot wounds.⁷ Krantz pioneered the use of CT scan in autopsies in the year 1983 and since then with the advent of new technologies in diagnostic radiology, postmortem imaging has increasingly been used.⁸ The foundation stone for use of digital autopsy was laid down after the generation of the "Virtual Mummy" at the British Museum in year 2004.⁹

Recently many studies have been conducted and being conducted to evaluate the advantages and feasibility of using imaging techniques in Virtopsy, in which majority claim the Virtopsy to be complimentary to and advantageous than the traditional autopsy, if not replacing.

2.1. Traditional autopsy and its challenges

There are some intrinsic drawbacks and challenges in a conventional autopsy that has been observed and reported from time to time.

1. The first and foremost is its extensive invasiveness leading to mutilation and disfigurement of the body.
2. There can be subjective error in interpreting the findings among different examiners.
3. Conventional autopsy is not reproducible since in some disputed cases the subsequent examination on the same body may be required.¹⁰

Some other concerns include the exposure of bodily contaminants of the corpse and the risk of transmission of infection to the personnel conducting the autopsy. It also requires substantial time and workforce and can be conducted only in limited hours during the daytime.¹¹

3. Virtual autopsy

Virtopsy, basically consists of

a) Assessment of body volume and analysis using CT, MRI, and micro radiology

b) 3D body surface imaging using forensic photogrammetry and 3D optical scanning.¹²

To achieve these basic assessments various techniques are used in the 'Virtopsy':

3.1. Photogrammetry and Surface Scanning

With a surface-scanning unit, a fringe pattern is projected onto the surface and is recorded by two cameras. A 3D image can be constructed using a 3D software. Another useful tool is digital photography which takes the photos of the surface from various angles. This data is then incorporated into the 3D software, enabling a true colour 3D surface reconstruction. This very accurate reconstruction can identify defects less than 1 mm in size. This technique can be used to identify minute injuries in corpses and living victims.^{13,14}

3.2. Computed Tomography Scanners

CT scanning is a commonly performed in clinical radiology resulting in a huge data of antemortem (AM) studies which can be used to compare with the postmortem CT scans. Prominent landmarks such as the paranasal sinuses, medical implants such as dental implants, bone screws and plates, pacemakers, and others can be used for comparison with PMCT databases for identification. This technology is even useful in cases of damaged body or putrefaction. Speed, reliability, and low costs compared to other means of identification such as DNA analysis is one of its advantages.^{15,16}

3.3. Magnetic Resonance Imaging

Another imaging technique complementing or even more powerful than CT is MRI. It has the ability to visualize soft-tissue organs which complements the ability of CT to visualize osseous lesions. The absence of motion in the corpses is an advantage which eliminates the motion artifacts allowing better visualization of anatomical details. One of the drawbacks is that the relaxation times T1 and T2 are temperature dependent which leads to changes in the image contrast with decreasing body temperature.^{17,18}

The new methods of 3-D/CAD-supported Photogrammetry and the medical imaging technique like the MSCT, MRI complement each other and by using this merging method of colored photogrammetric surface scan and gray-scale radiological images a high-tech wound documentation and visualization can be achieved. It has the advantage of being observer-independent, non-subjective, non-invasive, digitally storable, can be used any number of times for second opinion.^{15,19,20}

3.4. Post-mortem biopsy

With the use of CT or MRI organs of interest or specific pathologies can be visualized which helps in taking limited and minimally invasive biopsies with the use of CT guidance and a biopsy gun. In a similar way tissue and fluid samples can also be collected for toxicological and microbiological examinations.²¹

3.5. Post-mortem CT Angiography

Postmortem CT angiography helps in visualization of the whole cardiovascular system. Contrast will be seen as spillage. If there is any injury to a vessel making it visible in the CT images. This helps in detection of minute injuries to the blood vessels even to a capillary which are often missed in the conventional autopsy. At the same time angiography is not suitable to determine the findings in the heart muscles immediately after an ischemic attack which can be demonstrated in the conventional autopsy.¹⁹

To circulate the contrast in the post-mortem setting, a non-dynamic CT angiography has been developed which takes the help of a modified heart-lung machine.²²

3.5.1. Advantages of virtopsy

1. 3D constructs and animation based data will help in understanding and storing complex pathological findings which can be used as evidence in the court.
2. This data can be stored in a computer and can be assessed and used any number of times.
3. It is observer-independent and removes subjective error and gives results with more precision.
4. Forensic evidence is not touched not destroyed while conducting autopsy.
5. Difficult body areas that cannot be properly exposed in a traditional forensic autopsy, for example, pelvis or neck can be easily visualized without extensive dissection.
6. No risk of infection (e.g., tuberculosis, toxic substances)
7. Higher acceptance by the relatives, who do not tolerate and object to traditional forensic autopsy because of religious or cultural reasons.²

4. Discussion

Michael Thali and colleagues has conducted more than 100 autopsies in Switzerland at the University of Berne's Institute of Forensic Medicine and the findings of the Virtopsy procedure and the conventional autopsy were almost similar. The comparisons were based on points such as detection of gas, fractures and foreign bodies, as well as tissue and organ trauma. Thali says that there are very little aspects of forensic importance that the virtual autopsy cannot detect.²³

Mishra et al., showed that the average time taken for the declaration of death by PMCT and traditional

autopsy was 28 min (15 min- 1.2 h) and 11.3 h (4 h –5 days) respectively. The fractures of scapula and thoracic spine were detected only by PMCT which were missed on conventional autopsy. Similarly, air-containing lesions such as subcutaneous emphysema, pneumothorax, and pneumomediastinum were picked up only on PMCT. PMCT was also found significantly better in picking up hemothorax. Postmortem CT detected craniofacial fractures in all 41 patients (100%) while TA identified them in only 56%.²⁴

This was similar to the experience by Moskała et al., Daly et al., and Leth et al.^{25–27}

Hoey et al., in 2007 studied trauma victims with postmortem CT examinations, the study showed that imaging correctly identified the cause of death in 83% of cases and revealed as many as 40% of clinically significant findings that were missed on traditional autopsies.²⁸

Aghayev et al documented that in patients with blunt head injuries, the MSCT and MRI were far more superior in identifying the herniations of cerebellar tonsils. They also suggested that postmortem imaging is a good forensic visualization tool for documentation and examination of traumatic injury victims.²⁹

5. Conclusion

To conclude, there is a strong evidence against the acceptance of conventional autopsy as suggested by the declining number of autopsies. At the same time, we cannot totally remove the forensic expert out of the equation as we need the human eye, the experience and the expertise to evaluate and to get conclusions on certain things that aren't readily appreciated by the imaging techniques. We should also keep in mind that the imaging techniques are far better in capturing minute and important structures that can be of utmost value in arriving at a final decision. Thus, virtopsy is not the alternative to conventional autopsy but can be supportive and aids in achieving the perfect balance between the modern virtual autopsy and the old conventional autopsy. This review advocates a multidisciplinary research and advocacy to develop improved tools and protocols for better symbiotic relation between virtual autopsy and conventional autopsy to get the best out of the two.

6. Source of Funding

None.

7. Conflict of Interest

None.

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