Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta Morphologica et Anthropologica, 32 (1-2)
Sofia ● 2025

Review Articles

Advantages and Disadvantages of Virtual Autopsy in the Field of Forensic Medicine

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In forensic practice, the methodology of classical autopsy includes external examination of dead body, dissection of organs with identification of macroscopic pathologies and injuries and histopathology. In many forensic cases, the traditional autopsy is less accurate than the virtual one and often may destroy key forensic evidence. Some communities have religious objections to the autopsy and the search for a minimally invasive alternative in forensic practice is increasing. Autopsy is supported by diagnostic imaging techniques, e.g. computed tomography (CT) and magnetic resonance imaging (MRI). Compared to traditional autopsy, they have several advantages: non-invasive, the data can be visualized in situ, stored and fully interpreted at any time in cases of re-autopsy. Computed tomography is more accurate imaging technique for establishing the cause of death, presence of skeletal pathology and pathological abnormalities in fetuses, newborns and infants.

Key words: virtual autopsy, forensic examination, 3D scanning, tomography

Introduction

Traditional autopsy has changed little in the past century, consisting of external examination and evisceration, dissection of the major organs with identification of macroscopic pathologies and injuries, and histopathology if needed [20].

Medical imaging has become an indispensable part of diagnosis and treatment of patients in almost all medical disciplines. The process of a standard autopsy can

damage or destroy evidence of the cause and manner of death due to the elaborate, intense and timely surgical procedure. In light of this unfortunate and common issue, a new technology has been developed to eliminate hands-on autopsies i.e. virtual autopsy, which have a lot of potential applications [1, 3, 10].

3D scanning makes autopsies of decomposed bodies significantly easier, establishing key data that would be difficult to detect during traditional autopsies, such as the angle of entry of a knife or bullet or cases related to medical errors, etc. Advances in radiology, combined with advances in computer technology, have made 3D (three-dimensional) representation of anatomical structures easily accessible using CT and MR [13, 14, 18].

Virtual autopsy is a virtual alternative to a traditional autopsy, conducted with scanning and imaging technology. With virtual autopsy, radiation is used to examine the innards to reach a conclusion about the cause of death. A CT scan or an MRI could be used, in the same way that they are used to scan a living human's body [2, 5, 6, 12].

In Bulgaria, virtual autopsy has not yet been implemented in the departments of Forensic Medicine and Deontology of the Medical Universities. It would be a new aproach in Bulgaria, but exists as a practice worldwide. Its introduction as a new innovative method in forensic medical examinations of dead bodies in Bulgaria will lead to more accurate determination of cause of death, description of traumatic injuries and reconstruction of their mechanism.

Benefits of virtual autopsy

Virtual autopsy is a non-invasive method that allows identification of organs damage while preserving their topographic location, eliminating the possibility of iatrogenic damage. Additionally, it allows for repeated forensic analyses of dead body in cases of re-autopsy and exhumation: it requires a much shorter time to perform compared to conventional autopsy, there is no primary contact between the operator and the object for examination (corpse and remains), which will lead to optimization of automatic image analysis. Thus it has the potential to save costs, optimize resource allocation by automating tasks, reduce the risk of infection, as well as development of Burnout syndrome, which is common in forensic medical practice [11, 23, 29, 34].

Advantages of virtual autopsy:

1. Virtual autopsy is a non invasive technique where non-intrusive human autopsies are performed by using a CT scanner or MRI to obtain a detailed view of the body.
2. Virtual autopsy creates digital and permanent records of the body, making it easier for pathologists and clinicians to communicate with each other.
3. Real samples are hard to transport and share, while the digital image of the body can be shared electronically among medical professionals and experts and can be stored for future retrieval and re-examination.
4. Doctors can conduct virtual autopsy remotely. This means that hospitals centres with CT scanners can take advantage of virtual autopsy even though they may not have an in-house pathologist.
5. The legal system can also benefit from this technology as the 3-dimensional images can easily be shown in courtrooms and spare people from having to look at the traditional autopsies' gruesome pictures of the victim's body. The images from a

virtual autopsy can be made interactive, helping the judge and jury understand some technical facts.

6. Virtual autopsy leaves the body intact, so it would not add to the grief of the victim's family. This also overcomes the obstacles presented by religions that forbid cutting of the deceased.

7. Virtual autopsy is also a good method to eliminate cross contamination and infection, as all deceased are scanned in a body bag. It lowers the risk of contaminating pathologists and other medical specialists [34].

8. 3D scanning makes autopsies of decomposed, mummified and partially skeletonized bodies noticeable easier. It also determines key findings that are difficult to discover with traditional autopsy because they can be destroyed.

Disadvantages of virtual autopsy:

1. Virtual autopsy is expensive and includes high equipment and technology costs.

2. Virtual autopsy needs skills and training to deduce from the autopsy results. Lack of experience is a disadvantage [21, 27, 34].

3. Imaging alone cannot diagnose biochemical and toxicological causes, and is poor in the identification of asphyxial deaths. A minimally invasive autopsy service should include careful external examination of the body by a pathologist to identify superficial signs of injury not detected on imaging [20].

Appications of virtual autopsy in forensic practice

Which imaging technique should be used in forensic practice? Forensic pathologists use CT more often because it provides better spatial resolution than MRI and is effective for showing fractures and haemorrhages. Non-forensic and paediatric specialists use MRI because it provides greater detail of soft tissues than does CT. CT provides visualisation of coronary artery calcification that is not apparent with MRI, whereas acute myocardial infarcts might be seen with MRI but not with CT. CT has important practical advantages, being more widely available, less expensive, and quicker to do than MRI. CT could also be combined with angiography, increasing the accuracy of detection of vascular pathologies [9, 20].

Forensic examination, especially of deceased pedestrians in cases of car accidents, is a challenge in determining the position of the body relative to the vehicle based on the morphological characteristics of the identified traumatic injuries. The application of virtual autopsy in these cases successfully allows the identification of bruises, subcortical hematomas on long bones, which is impossible with conventional autopsy. The latter allows localization of the primary contact with motor vehicles. Digital storage of the established results of traumatic injuries of internal organs and bones would allow a detailed analysis of their mechanism of injury with subsequent detailed reconstruction of the car accident [15, 17, 26].

Cases of falls from a height are always accompanied by multiple injuries of the internal organs and bones. In conventional autopsy, these cases are often associated with difficult dissection of the soft tissues around the traumatically damaged bones. This makes it impossible to detect the fracture and/or accurately determine the fracture line and reconstruct the type of fall based on the mechanism of bone damage. With virtual autopsy, this drawback is completely eliminated [7, 16, 30].

In forensic medicine, in cases of drowning, proving viability and determining the length of time the dead body has been in the water, is almost impossible. Several imaging studies have been described that virtual autopsy can help in such cases [4, 16, 20, 25].

The application of virtual autopsy in cases of child mortality is of utmost importance to differentiate the Child abuse syndrome. The detection of Bucket handle fractures of the long bones is one of the main signs proving physical abuse of a child. These microfractures are impossible to detect during a conventional autopsy, which makes this type of autopsy insufficient in such cases [28, 29, 31].

In cases of death from gunshot wounds, forensic analysis is mainly related to determining the entry-exit wound and the wound channel. The application of 3D reconstruction with virtual autopsy allows for accurate determination of direction of passage of the projectile through the body, since the topographical location of the organs is preserved, unlike conventional autopsy [8, 22, 24, 32].

Using a 3D virtual dissection table allows us to examine 3D images of human body using CT or MRI data and could help forensic pathologist to locate vital anatomical structures (e.g. bone fragments, variable positions of anatomical structures, position of foreign bodies, presence of pneumothorax, air embolism or subcutaneous emphysema, etc.). To achieve good image quality in 3D imaging, thin slices (< 1 mm) and the use of correct scanning protocols for specific tissues, organs and pathology are required. Investigators can intuitively zoom in, rotate or crop the visualized body without using a scalpel or destroying the object. This means that the same image can be used multiple times, which is a valuable aspect in forensic autopsies. The idea of interacting with virtual patients is to provide a better understanding of the anatomy of the body, which in turn will contribute to higher autopsy efficiency [19, 33]. The combination of computed tomography and three-dimensional examination with a virtual dissection table in forensic practice is an innovative approach in the search of more successful methods for diagnosing the causes of death. It will provide more in-depth data in detailed reconstruction of traumatic injuries. This, in turn, will contribute to the modernization of forensic medicine and will facilitate the diagnostic process for medical specialists.

In summary, the virtual autopsy approach has the following advantages: allows for objective data archiving without tissue and organ destruction; minimally invasive; provides life-size documentation; preservation of forensic evidence without iatrogenic damage; provides an alternative or additional tool for examination in “difficult body area autopsy” (e.g. face, neck, pelvis); can be used in cultures and situations where autopsy is not tolerated by religion or is rejected by family members (e.g. psychological reasons); provides the ability to examine bodies contaminated with infection, toxic substances, radionuclides or other biological hazards (i.e. bioterrorism); provides 2D and 3D post-processing for visualization of the autopsy by non-attending specialists during the procedure; provides greater clarity in court and creation of digital archives (database for teaching and training).

Conclusions

Virtual autopsy is a necessary addition to the traditional autopsy in forensic medical practice nowadays. Using both methods of investigation in combination could be of great benefit in teaching medical students, residents and PhD students in forensic medicine and imaging diagnostics in order to increase their level of competence and will contribute to knowledge transfer in the field of forensic medicine by creating a database of virtual autopsies for further comparative analysis.

Acknowledgements. This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project **№ BG-RRP-2.004-0007-C01.**

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