

Digital Virtual Autopsy: Need of the Hour in India

Arijit Dey¹, Neha Sharma², Abhishek Yadav³, Kulbhushan Prasad⁴, Sudhir K. Gupta⁵

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Abstract

Autopsy includes a thorough examination of a cadaver related to cause and manner of death. Digital autopsy refers to the use of modern medical imaging and computer technologies to obtain the images of internal body structures and organs of human body in a non-invasive or minimally invasive manner, detect the injuries, diseases and other morphological changes in human body, and provide the evidence to determine the cause and manner of death. Compared to traditional technologies, post-mortem forensic imaging methods are non-invasive, repeatable and are more conducive to resolving the key issues in several cases. It is being applied in few developed countries such as Switzerland, England, USA, Japan, etc. and is rapidly gaining importance. It can be used judiciously in estimating time since death, establishing identity of an individual, for age and sex determination, sudden death cases, road traffic accident cases, asphyxial deaths, death due to thermal injury, in Gunshot injuries, in decomposed bodies, in disaster scenarios, etc. However, it has still not been applied to the field of Forensic Medicine in India. This article emphasizes the utility of this method and focuses on its urgent need in India.

Keywords: Digital Autopsy; Image processing; Radiology; Cause of death.

Introduction

Recent scientific technologies have advanced to the level that different disciplines are interconnected to solve problems in the field of Forensic Medicine. It is a specialty used in judiciary that involves systematic application of knowledge involving the collection of data through observation and experimentation, leading to solution of a medicolegal problem. In the context of globalization, the importance of scientific evidence has been increasingly highlighted, and

^{1,2}Senior Resident, ^{3,4}Assistant Professor, ⁵Professor & Head, Dept. of Forensic Medicine & Toxicology, All India Institute of Medical Sciences, New Delhi 110029, India.

Correspondence and Reprint Requests: Arijit Dey, Senior Resident, Department of Forensic Medicine, All India Institute of Medical Sciences, New Delhi 110029, India.

E-mail: arijit.forensic@gmail.com

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the conclusions made by forensic experts are important scientific evidence. Traditional forensic medical examination includes visual inspection and experience-based judgment during autopsy and histopathological examination. Improper forensic evidence may lead to contradictions and conflicts between people involved in the case and investigators. In recent years, with the development of science and technology, the integration of forensic pathology, medical imaging technology, computer technology, and other disciplines formed a series of new post-mortem forensic imaging methods, bringing a revolutionary breakthrough in forensic science [1,2]. Compared to traditional technologies, post-mortem forensic imaging methods are non-invasive, repeatable and are more conducive to resolving the key issues in several cases [3,4]. Autopsy means "to see with own eyes," derived from Greek words "autos" meaning "self" and "opsomei" means "I will see." Digital autopsy is the application of digital technologies to aid in the process of Postmortem examination by the Autopsy surgeon. Digital autopsy is a multi-disciplinary technology that combines forensic medicine and pathology, radiology, physics, and computer graphics [5]. Conventional autopsy involves invasive procedures that are the traditional means of postmortem examination; however,

Digital autopsy is a minimally invasive emerging technology in the field of forensic medicine that incorporates imaging technology of radiologists and forensic medicine experts.

Digital Autopsy based on modern imaging technology

In all cases involving sudden, unnatural and suspicious death, identifying the cause of death is often difficult and challenging task. The primary focus of the autopsy surgeon is to determine the cause of death, manner of death, and assessment of fatal and non-fatal injuries and scene reconstruction if it is possible. Forensic autopsy is recognized as the gold standard for a clear cause of death. But, it has limitations in the examinations of special parts of the body, the change or destruction of the body due to the autopsy operation and various internal and external factors, lacunae in histopathological examination, etc., the autopsy cannot always provide sufficient information to determine the cause of death [6]. Also, traditional autopsy is a destructive examination, and the family of the deceased often resists conduction of autopsy, especially due to the repulsion and rejection on religious and cultural beliefs [7]. The development of multi-detector computed tomography (MDCT), magnetic resonance imaging (MRI) and other medical imaging technologies provides a non-invasive/minimally invasive autopsy approach for the forensic examination, i.e. Digital autopsy. This technology provides a clear observation of lesions and damages on cadaveric organs, bones and tissues [8]. The image data can be saved, and re-examined in future, and this technology has a significant value for the detection of forensic injury and determination of the cause of death [9].

The findings of traditional autopsy and digital autopsy can be compared and analyzed, which will yield a more objective judgment compared with that obtained by a traditional autopsy alone [10]. Systemic researches of Digital autopsy started in Switzerland [11] and later spread to the United States, [12] Japan, [13] England [14] and many other countries. These developed nations have carried out post-mortem forensic imaging projects that integrate multiple technologies focused on the determination of the cause of death, forensic pathological detection, vital reactions, the reconstruction, reproduction and imaging of injuries, and other key aspects in forensic science.

Procedure of Digital Autopsy

In Digital Autopsy, there is fusion of medical 3D imaging techniques as well as a 3D surface scan to map the external surface of a body. The process records and documents a detailed 3D image of the body surface area. The body is kept covered inside a bag through which X-rays can easily pass, in order to prevent contamination. The scan utilizes cameras to capture colored body image, and then the body is laid on the sliding table of the CT and MRI machine. The bag remains closed while the body is scanned not only to respect privacy of the dead, but also to maintain hygiene of the room. CT scan is completed in 20 sec and up to 25,000 images are acquired; each image is a slice through the body. The information from the interior and surface scans is supplied to powerful computers where these data are combined using computer-aided programs and graphics processors. Within 10 minutes, a concise, detailed image of bone and tissue are reconstructed using computers, from the data representing thin X-ray slices of the body. These images can be manipulated and rotated at various angles, providing instant flexibility to the viewer. If internal body samples are needed, a needle biopsy can be done after analyzing the 3D model, internal and surface scans. All the data scanned are then captured and saved on compact discs [15].

Applications of Digital autopsy

Timing of death: This can be determined by Digital autopsy using changes seen in both CT and MRI in head injury cases [16].

Establishing Identity of individuals: Comparison of CT scan of an unidentified cranium with ante mortem CT scan of a man reported to be missing established identity of a deceased individual [17]. Dental identification procedures involve comparison between postmortem and ante mortem data, and are compulsory for dental identification, which is obtained principally by visual examination. However, visual examination is difficult in charred bodies, where Digital autopsy can be applied as a quick, reliable way for getting postmortem records [18].

Digital autopsy for age and sex determination: Sex determination in forensic practice involves examination of sexually dimorphic bones such as pelvic bones. CT scan provides an easy and fast method for depicting and measuring bone structures prior to autopsy.

Digital autopsy in road traffic accident: Postmortem CT and MRI were done in three cadavers of fatal blunt head injury, which showed extensive hard and soft tissue injuries of the head and signs of high intracranial pressure with herniation of the cerebellar tonsils; these findings corroborated with those of traditional autopsy, which was done after the digital autopsy [19].

Digital autopsy in Asphyxial Deaths: A case series of postmortem CT and MRI of nine persons has been reported, who died from hanging or manual strangulation. The neck findings were compared with those found during traditional autopsy. The report concluded that CT and MRI revealed strangulation signs similar to forensic pathology findings [20]. Plattner reported a case report of drowning, whereby the findings of a massive vital decompression with pulmonary barotrauma and lethal gas embolism were identified in radiological images [21].

Digital autopsy in sudden death: Sohail et al. determined the utility of CT scan in establishing the cause of death among male prisoners dying in Karachi jails, and concluded that CT was equally effective as traditional autopsy in identifying pulmonary infections and natural causes of death [22].

Digital autopsy in death due to thermal Injury: Thali et al. reported a completely charred body of a single motor vehicle accident with a post-crash fire. The radiological methods of CT and MRI helped to document the thermal injuries caused by burn as well as the forensic relevant vital reactions and concluded that postmortem imaging is a good forensic tool with a great potential for the forensic documentation and examination of completely charred bodies [23].

Digital autopsy in Gunshot injuries: A case series of eight gunshot victims were scanned by CT and MRI and the data were interpreted with subsequent correlation of findings from classical autopsy. The CT and MRI examinations with the subsequent two-dimensional multi-planar reformation helped document the entire gunshot created complex skull fractures and brain injuries in complete graphic detail [24].

Advantages of Digital autopsy

Digital autopsy can be used to examine the entire body, without loss or destruction of forensic evidence. It is repeatable, and can record the actual size of the lesions. The archived data can

be used for consultation and re-examination, and 3D information can be provided as intuitive evidences in court [25]. Digital autopsy can examine complicated body structures and areas not included in conventional autopsy, and can also be applied to ancient, highly decomposed bodies or bodies contaminated by infectious diseases, toxic substances, or other biohazards [26]. When there are strong cultural objections or objections from family members and it is not possible to perform autopsy, Digital autopsy can serve as an alternative method to collect evidence for determining the cause of death. This process allows a digital re-examination of the body after liberation of the crime scene and burial of the corpse. These images can also be used for teaching and research purposes and also applied in teleforensic or telepathology.

Limitations

Post-mortem forensic imaging has certain limitations. The quality of image acquired depends on device performance, scanning parameters, body condition and operators' personal judgments [27]. The true color of tissues may not be appreciated and artifacts may appear during the scanning. In addition, digital autopsy requires costly equipment, and is difficult for general institutions to perform the related research.

Conclusion

Traditional autopsy has its own mark on the postmortem table, so does the virtual 3D image of a decomposed body as it lends its futuristic advancements to maintain the privacy of a dead person and end the last chapter of life with perfection. Currently, several institutions are carrying out research related to post-mortem forensic imaging and virtual autopsy. Similar to other technologies, post-mortem forensic imaging has its own unique strengths and weakness. In a developing country like India, the traditional postmortem examination cannot be completely replaced at present. However, the application of Digital autopsy will become increasingly prominent and recognized. Thus, advanced technology like Digital autopsy is need of the hour in Indian context. Department of Forensic Medicine & Toxicology, AIIMS, New Delhi is the first of its kind in South East Asian Region, to start Digital autopsy in Forensic Medicine. The department had presented a proposal in front of competent authorities of ICMR, and after thorough deliberation and discussion, ICMR has approved the implementation of this technology for research, academic and medicolegal purposes.

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