Review Article

An Update on Virtopsy- A Modern Forensic Investigation Tool

Mushtaq Ahmad [1], Md Zubaidur Rahman [2], Farial Naima Rahman [3].

Abstract

Virtopsy is a virtual alternative to a traditional autopsy, conducted with scanning and imaging technology. In developed countries Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are now being evaluated as complementary means for determination of cause of death. This paper explores the latest development and implication of virtopsy from ethical, clinical and technical point of view. Published literature in different journals with strict inclusion and exclusion criteria were extensively reviewed through use of general and Meta search engines to elucidate the applications and implications of virtual autopsy. The modern high-resolution imaging has been used as a well described aid in the setting of post-mortem investigations. Virtopsy introduces a new era in autopsy examination. It utilizes the technological innovation of modern imaging system to obtain best results and three Dimensional (3D) images of the body in multiple plains without mutilation of the human body. Now a days virtopsy is very much acceptable procedure to the forensic society. In western worlds virtopsy is likely to replace conventional autopsies in future. We can also try to implement this modern system in our country.

Key words: *Virtopsy, Forensic investigation.*

Date of received: *01.11.2020*

Date of acceptance: *25.02.2021*

KYAMC Journal. 2021;12(01): 48-52.

DOI: https://doi.org/10.3329/kyamcj.v12i1.53369

Introduction

Virtopsy is a virtual alternative to a traditional autopsy, conducted with scanning and imaging technology. The name is a portmanteau of 'virtual' and 'autopsy' and is a trademark registered to Prof. Richard Dirnhofer (de), the former head of the Institute of Forensic Medicine of the University of Bern, Switzerland.[1] The term “virtual” in this context apparently is meant in both the modern and original senses. Virtual's Latin root word “virtus” (virtue) implies the qualities of capability, efficiency, effectiveness and objectivity. However, some proponents propose to replace traditional autopsy with this approach.[2,3] "Virtual" also has the sense of "digital" or refers to virtual reality respectively. The modern high-resolution imaging like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) has been used as a well described aid in the setting of post-mortem investigations.[4-6]

This paper explores the implication of virtopsy from ethical , clinical and technical point of view. In this article the history of forensic autopsy and the reasons for the gradual decrease in conventional autopsy rates over the last few decades have been briefly described. An overview of advantages and limitations of modern imaging autopsy techniques and potential future applications of modern imaging techniques in postmortem analysis are also discussed.

Published literature with strict inclusion and exclusion criteria were extensively reviewed through use of general and Meta search engines to elucidate the applications and implications of virtopsy. Articles containing information regarding the history of virtopsy, its application in different cases, and gradual development of the procedures in western countries, future aspects of this method have been taken into count for collection of data and references.

1. Col (Dr) Mushtaq Ahmad, Professor & HOD of Forensic Medicine, Armed Forces Medical College, Dhaka, Bangladesh.
2. Dr Md Zubaidur Rahman, Associate Professor & HOD of Forensic Medicine, Khwaja Yunus Ali Medical College, Sirajgonj, Bangladesh.
3. Dr Farial Naima Rahman, Lecturer, Dept of Forensic Medicine, Armed Forces Medical College, Dhaka, Bangladesh.

Correspondence: Col (Dr) Mushtaq Ahmad, Professor & HOD of Forensic Medicine, Armed Forces Medical College, Dhaka, Bangladesh. Email: mushtaq863@yahoo.com, Mobile: 01711-140546.

Discussion

Autopsy is a special type of scientific examination of a dead body carried out under the law of state. A model autopsy procedure has been produced by United Nations within the context of investigation of human rights abuses called the-'Minnesota Protocol ' (The United Nations Manual on the Effective presentation and investigation of extra legal, arbitrary and summary execution). It can be used to deal with difficult, controversial or sensitive cases.[7] The word "autopsy" has come from the Greek words – "Autos"- which means self and "opis" which means view or to see for one self. It is also called necropsy. ("Necros" means- dead body) or post mortem examination ("post"- means after, "mortem" means death).[8]

The first medico legal autopsy was done by Bartolomio De Varignana in Italy in 1302.[9] In this Subcontinent the first medico legal autopsy in India was performed by Dr Edward Bulkley on 28th August 1693.[10] The first organized treatise on pathological findings at autopsy was "The seats and causes of diseases investigated by anatomy", published in 1761 by Giovanni Batista Morgagni when he was 79 years old. This book, describing nearly 700 autopsies performed by the author, is the foundation of modern post-mortem science. At the end of the nineteenth century, Osler established autopsy as one of the cornerstones of his approach to both medical training and clinical method .[11-13] In the first half of the twentieth century autopsy rates steadily increased. But over the past three decades, there has been a 40-50% drop in autopsy rates across the world.[14] In the United States, traditional autopsy rates fell from the reported high of 41% in the 1960's to between 5% and 23% at present.[15-17] The most commonly cited factors accounting for this phenomenon include physician discomfort in requesting permission from the family, cost containment measures, risk of blood borne pathogen transmission, as well as the perceived absence of the curricular/educational value of autopsies.[18-24]

The Virtopsy, or "virtual autopsy" was developed by Richard Dirnhofer, former Director of Forensic Medicine, Berne, which was then continued by his successor, Michel Thali and his colleagues at the University of Berne's Institute of Forensic Medicine, Switzerland.[1,4,24,25]

A research team from the Institute of Forensic Medicine, University of Berne, Switzerland suggested a project on virtopsy as an alternative to the conventional autopsy. Total number of 40 forensic cases until the year 2006 were examined through multislice CT (MSCT)/NMR and conventional autopsy and comparative evaluation of radiological and conventional autopsies was done taking five aspects into account viz. medical causes of death, relevant morphopathological modifications, vital responses, lesion reconstruction, death cause reexamination, and visualization. In determining the medical cause, 55% causes of death discovered in autopsy were identified through imagistic methods independently.[2, 25]

A multi-section computed tomography (MSCT), Micro CT, MRI, MR Microscopy, MR Spectroscopy (MRS) and three dimensional photogrammetric based optical surface scanning visualize the interior of the body for collection of all the data in details in regards to condition of different organs. MRS is a technique in virtopsy which helps in determining the metabolic concentrations in the tissues, thus helping in estimating the time of death. MR microscopy is a microimaging technique which is used to study the soft tissue injuries like retinal hemorrhage, electric injury to the skin, etc. Micro tomography is used to study the weapon involved and its injury patterns.[24-27]

Specific software (e.g. Tera Recon Aquarius NET®, Foster City, California, United States of America) allowed for 3D reconstructions of the computed tomography images from the observed structures. Another part of the documentation concerns the body surface recording, performed by forensic photogrammetric and 3D optical scanning. One can examine the part of the body slice by slice in different planes according to the requirement of the situation. Apart from these, using the magnetic resonance imaging spectroscopy, time since death can also be estimated by measuring metabolites in the brain, emerging during postmortem decomposition. The samples for histopathological examination if required can be collected more precisely using CT guided needle biopsy. Postmortem angiography is used to visualise the cardiovascular system.[28,29]

Since 2005, United States Army Forces Institute of Pathology has scanned and analyzed about 800 bodies killed in war zones in order to determine cause of death and examine the injuries. In 2007, Levy et al published a series of postmortem CT examinations of military air mishap victims describing pockets of ectopic air in various anatomic areas in 24% of victims. They also noted that detection of solid organ injury and superficial traumas were significantly worse on CT than on a traditional autopsy.[30] The application of virtopsy is diversified. It can be applied in a broad number of forensic situations, such as critical forensic investigations; carbonized , charred and putrefied body identifications; mass disaster cases; age estimation; anthropological examinations and skin lesion analyses, determining cause of death and decedent gender, identification in difficult forensic cases, body length and Individual decedent feature identification; identifying distinct foreign bodies – retained bullets, blades etc, identification of injuries and forensic three dimensional reconstructions, bullet tract identification; education and clinical performance improvement process and research purposes.[31,32]

Virtopsy in court can also play a major advantage. Virtopsy provides excellent tools for crime and accident evidences. It portrays 3D analysis of internal injuries, 3D true color representations of surface injuries and even 3D scaled models of entire crime scenes and events which is of great help during court scenes. The Virtopsy approach shows critical forensic evidence in an unbiased, which is used as an evidence to laypersons and legal professionals.[33,34] Several studies have compared the value of virtopsy with a traditional autopsy and suggested that virtopsy could reveal internal injuries which may be missed by a traditional autopsy.[34-36] Studies have shown that postmortem CT scans could provide valuable information in the evaluation of victims who succumbed to a variety of fatal events, including gunshot wounds, blunt trauma, airplane accidents and drowning.[37-39]

The other advantages of virtopsy include the 3D illustration and real scientific animation based on real data improve also the understandability of complex pathological findings, respectively, forensic evidence in court • Digital stored data (3D images) on computers is accessible any time • The whole process is observer independent and results in an objective

data archiving because of mechanical precision • No forensic evidence is touched or even destroyed • Examination of difficult body areas for traditional forensic autopsy, for example, pelvis or neck, a body can be scanned from "tip to toe" • No risk of infection (e.g., tuberculosis, toxic substances) and • Higher acceptance by the relatives, who do not tolerate and object to traditional forensic autopsy because of religious or cultural reasons.[40] Thali et al 37 have shown that virtopsy in gunshot wound victims is useful to localize the bullet in three dimensions, document the bullet path, visualize fracture patterns associated with gunshot wounds, and evaluate internal organ injury prior to autopsy.[41]

Previous studies also relates the role the forensic odontologist on age estimations. In one study over 40% of postmortem CT studies revealed clinically significant findings that were not identified on traditional autopsy.[42-45] Imaging autopsies provide visualization of soft tissue patterns in cases of severe putrefaction. Aghayev et al described the use of both MSCT and MRI to document herniation of cerebellar tonsils prior to traditional autopsy in patients with blunt head injuries.[46] The same group also advocated postmortem imaging as a good forensic visualization tool for documentation and examination of traumatic injuries and other pathologic findings in a broad range of scenarios.[47] Oyake et al conducted an study to help determine the etiology of sudden death due to non-traumatic causes in infants and children and were able to point to the cause of death in 14 of 15 decedents when radiographic information was combined with pre-mortem clinical and laboratory data.[48-50]

Now a days Medical imaging database is investigated, stored and analyzed by radiologists using a Picture Archiving and Communication System (P A C S). All PACSs have a Multi Planar Reformation (MPR) tool, allows the investigator to reformat images in the axial, coronal and sagital image plane. This provides image in three dimension and reviews better analysis. Other technique to display the image database as a whole is the Volume Rendering procedure. Similar to windowing, a transparency and a color is given to each pixel, based on its Hounsfield value. This 'defining' is called transfer function. As the x-ray densities of different tissues and pathologies are known already, predefined transfer functions allow the depiction of bone, soft tissue and skin in color. An animation software 3D studio MAX is used which allows the polygon models (bones, surface etc.) to be imported directly. A virtual bone system for animation (biped) can be created to better analyze the properties of the polygon model that is to be animated .[51-56]

Like all other latest inventions, virtopsy also has a number of disadvantages. Autopsy still produces both different and ancillary findings compared to Virtopsy results so that currently, virtopsy is not a generally accepted method to entirely replace autopsies. It is not possible to distinguish all the pathological conditions with this modern technique. Virtopsy cannot give the infection status. In virtopsy it is difficult to differentiate antemortem or the postmortem wounds, difficult to appreciate the postmortem artifacts and the colour changes. In some cases small tissue injury may also be missed.

Conclusion

Presently, the imaging techniques are excellent tools used for forensic medicine. In comparison to other methods, they are able to capture the findings at the moment of investigation without causing any damage and provides better analyses. Now a days virtopsy is very much acceptable procedure to the forensic society. In western worlds virtual autopsy is likely to replace conventional autopsies in future. We can also utilize this modern technology to upgrade the forensic investigation system in our country.

Acknowledgement

We express our gratitute to Prof. Dr. Md. Zulfikar Ali, Dept of Medicine, Khwaja Yunus Ali Medical College, Sirajgonj, Bangladesh.

References

1. Thali MJ, Yen K, Schweitzer W, Vock P, Boesch C, Ozdoba C, "Virtopsy, a new imaging horizon in forensic pathology: virtual autopsy by postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI)--a feasibility study". J Forensic Sci.2003; 48 (2): 386–403.

2. Dumbrava DP, Anitan S, Siserman C, Fulga I, Opincaru I. Virtopsy: An alternative to the conventional autopsy. Rom J Leg Med 2010;18:75-78

3. Ward HE, Clarke BE, Zimmerman PE, Cleary MI. The decline in hospital autopsy rates in 2001. MJA 2002;176:91.

4. Thali MJ, Braun M, Buck U, Aghayev E, "Virtopsy--scientific documentation, reconstruction and animation in forensic: individual and real 3D data based geo-metric approach including optical body/object surface and radiological CT/MRI scanning". J Forensic Sci. 2005; 50 (2): 428–442.

5. Aghayev E, Staub L, Dirnhofer R, et al. "Virtopsy - the concept of a centralized database in forensic medicine for analysis and comparison of radiological and autopsy data". J Forensic Leg Med. 2010; 15 (3): 135–140.

6. O'Donnell C, Woodford N. "Post-mortem radiology--a new sub-speciality?". Clin Radiol. 2008; 63(11):1189–1194.

7. James JP, Jones R, Karch SB, et al. Simpson's Forensic Medicine 13th ed.London: Arnold: 2011. 31-34.

8. Biswas G. Review of Forensic Medicine & Toxicology. 2nd ed. New Delhi :Jaypee : 2012. 83-85.

9. Reddy KSN. The Essentials of Forensic Medicine & Toxicology. 31st ed. Hyderabad : Medical Book Coy :2012. 1-7.

10. Mathiharan K, Patnaik AK. Modi;s Medical Jurisprudence and Toxicology. 23rd ed. : Butterworts :. 2005. 1-8.

11. Dedouit F, Telmon N, Costaglioga R, Otal P, Joffre F, Rougé D. Virtual anthropology and forensic identification: Report of one case. Forensic Sci Int 2007;173:182-187.

12. Hill RB, Anderson RE. The recent history of the autopsy. ArchPathol Lab Med 1996;120:702-712.

13. Rutty G. Are autopsies necessary? The role of computed tomography as a possible alternative to invasive autopsies. Rechtsmedizin 2007;17:21-28.

14. Saukko P. Medicolegal investigative system and sudden death in Scandinavia. Nihon Hoigaku Zasshi 1995;49:458-465.

15. Lindstrom P, Janzon L, Sternby NH. Declining autopsy rates in Sweden: a study of causes and consequences in Malmo, Sweden. J Intern Med 1997;242:57-165.

16. Loughrey MB, McCluggage WG, Toner PG. The declining autopsy rate and clinicians' attitudes. Ulst Med J 2000;69:83-89.

17. Burton EC, Phillips RS, Covinsky KE, The relation of autopsy rate to physicians' beliefs and recommendations regarding autopsy. Am Journal Med 2004;117:255-261.

18. Corona T, Rembao D, Sotelo J. Improving the autopsy rate in a teaching hospital. Arch Pathol Lab Med 2003;127:1408-1409.

19. Grossman MD, Stawicki SP. The impact of human immunodeficiency virus (HIV) on outcome and practice in trauma: Past, present, future. Injury 2006;37:1117-1124.

20. Lundberg GD. Medicine without the autopsy. Arch Pathol Lab Med 1984;108:449-454.

21. O'Grady G. Death of the teaching autopsy. BMJ 2003;237:802-803.

22. Welsh TS, Kaplan J. The role of postmortem examination in medical education. Mayo Clin Proc 1998;73:802-805.

23. Combes A, Mokhtari M, Couvelard A, Trouillet JL, Baudot J, Hénin D, Clinical and autopsy diagnoses in the intensive care unit: a prospective study. Arch Intern Med. 004;164:389-392.

24. Thali MJ, Jackowaski C, Oesterhelweg L, Ross SG, Dirnhofer R. Virtopsy: The Swiss virtual autopsy approach. Leg Med (Tokyo) 2007;9:100-104.

25. Thali MJ, Braun M, Buck U, Aghayev E, VIRTOPSY-scientific documentation, reconstion and animation in forensic: individual and real 3D data based geometric approach including optical body/object surface and radiological CT/MRI scanning, J Forensic Sci. 2005;50(2):428-442.

26. Dirnhofer R, Jackowski C, Vock P, VIRTOPSY: minimally invasive, imaging-guided virtual autopsy. Radiographics, 2006;26 (5):1305-1333.

27. Buck U, Naether S, Braun M, Application of 3D documentation andgeometric reconstruction methods in traffic accident analysis: with high resolution surface scanning, radiological MSCT / MRI scanning and real data based animation. Forensic Sci Int, 2007;170 (1):20-28.

28. Thali MJ, Yen K, Vock P, Ozdoba C, Kneubuehl BP, Image-guided virtual autopsy findings of gunshot victims performed with multi-slice computed tomography and magnetic resonance imaging and subsequent correlation between radiology and autopsy findings, Forensic Sci Int. 2003;138(1-3):8-16.

29. Flodmark O, Becker LE, Harwood-Nash DC, Correlation between computed tomography and autopsy in premature and full-term neonates that have suffered perinatal asphyxia. Radiology. 1980;137:93 -103.

30. Levy G, Goldstein L, Blachar A, Postmortem computed tomography in victims of military air mishaps: radiological-pathological correlation of CT findings. Isr Med Assoc J 2007;9:699-702.

31. Paperno S, Riepert T, Grug B, Value of postmortem computed tomography in comparison to autopsy. Rofo 2005;177:130-136.

32. Ahmad M, Rahman FN. Virtual Autopsy: A New Trend in Forensic Investigation. JAFMC Bangladesh. 2013;9(2): 100-106.

33. Virtopsy: an aid in forensic investigation Surabhi, Taniya Malhotra, Sumit Bhateja, Geetika Arora IP International Journal of Forensic Medicine and Toxicological Sciences 2019;4(4):95-98

34. Scholing M, Saltzherr TP, Fung Kon Jin PH, The Value of Postmortem Computed Tomography as an Alternative for Autopsy in Trauma Victims: A Systematic Review. Eur Radiol 2009; 19(10):2333-2341.

35. Fetisov VA, Kuprina TA, Sinitsyn VE, The Foreign Experience with the Application of the Modern Radiodiagnostic Methods for the Estimation of Prescription of Death Coming and Time of Infliction of Injury. Sud Med Ekspert 2016; 59(2):47-54.

36. Bolliger SA, Thali MJ, Ross S, Virtual Autopsy Using Imaging: Bridging Radiologic and Forensic Sciences. A Review of the Virtopsy and Similar Projects. Eur Radiol 2008; 18(2):273-282.

37. Levy AD, Abbott RM, Mallak CT, et al. Virtual Autopsy: Preliminary Experience in High-Velocity Gunshot Wound Victims. Radiology 2006; 240(2):522-528.

38. Levy G, Goldstein L, Blachar A, Postmortem Computed Tomography in Victims of Military Air Mishaps: Radiological-Pathological Correlation of CT Findings. IMJ 2007; 9(10):699-702.

39. Aghayev E, Thali MJ, Sonnenschein M, Fatal Steamer Accident; Blunt Force Injuries and Drowning in Post-Mortem MSCT and MRI. Forensic Sci Int 2005; 152(1):65-71.

40. Vadivel JK. Virtual autopsy. Int J Forensic Odontol 2016;1:14-16.

41. Thali MJ, Yen K, Plattner T, et al. Charred body: virtual autopsy with multi-slice computed tomography and magnetic resonance imaging. J Forensic Sci 2002;47:1326-1331.

42. Dedouit F, Telmon N, Guilbeau-Frugier C, Virtual autopsy and forensic identification – practical application: are port of one case. J Forensic Sci 2007;52:960-964.

43. Bassed RB, Hill AJ. The use of computed tomography (CT) to estimate age in the 2009 Victorian Bushfire Victims: a case report. Forensic SciInt 2011;205:48-51.

44. O'donell C, Lino M, Mansharan K. Contribution of post mortem multidetector CT scanning to the identification of the deceased in a mass disaster: experience gained from the 2009 Victorian bushfires. Forensic Sci Int 2011;205:15-28.

45. Cordner SM, Woodford N, Bassed R. Forensic aspects of the 2009 Victorian Bushfires Disaster. Forensic Sci Int 2011;205:2-7

46. Aghayev E, Yen K, Sonnenschein M, Virtopsy post-mortem multi-slice computed tomography (MSCT) and magnetic resonance imaging (MRI) demonstrating descending tonsillar herniation: comparison to clinical studies. Neuroradiology 2004;46:559–564.

47. Aghayev E, Thali MJ, Jackowski C, MRI detects hemorrhages in the muscles of the back in hypothermia. Forensic Sci Int 2008;176:183-186.

48. Oyake Y, Aoki T, Shiotani S, Postmortem computed tomography for detecting causes of sudden death in infants and children: retrospective review of cases. Radiat Med 2006;24:493-502.

49. Aghayev E, Thali MJ, Sonnenschein M, et al. Post-mortem tissue sampling using computed tomography guidance. Forensic Sci Int. 2007, 166:199-203.

50. Polacco M, , Pasquale DA, Francesco, et al. Virtual Autopsy in Hanging. American Journal of Forensic Medicine & Pathology: June 2013 :34 (2). 107–109.

51. Levy AD, Abbott RM, Mallak CT, et al. Virtual autopsy: preliminary experience in highvelocity gunshot wound victims. Radiology 2006; 240: 522.

52. Thali MJ, Barun M & Dirnhofer R. Optical 3D surface digitizing in Forensic Medicine: 3D Documentation of skin and bone injuries, Forensic Sci Innt, 2003,Nov26:137(2-3):203-208.

53. Hayakawa M, Yamamoto S, Motani H. Does imaging technology overcome problems of conventional postmortem examination A trial of computed tomography imaging for postmortem examination. Int J Legal Med 2006;120:24-26.

54. Thali MJ, Braun M, Buck U, Virtopsy - scientific documentation, reconstruction and animation in forensic: individual and real 3D data based geo-metric approach including optical body/object surface and radiological CT/MRI scanning. J Forensic Sci 2005;50:428-442.

55. Levy AD, Harcke HT, Getz JM, et al, Galvin JR. Virtual autopsy: Two- and three-dimensional multidetector CT findings in drowning with autopsy comparison. Radiology 2007;243:862-868.

56. Birngruber CG, Obert M, Ramsthaler F, Comparative dental radiographic identification using flat panel CT. Forensic Sci Int 2011;209:31-34.