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Reimagining forensic investigation: The legal status and future of virtual autopsy in India

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Abstract:
Virtual autopsy (virtopsy) uses post-mortem computed tomography and magnetic resonance imaging to examine the deceased without dissection. Therefore, it is of interest to assess the legal status of virtopsy within the Indian medico-legal framework. Imaging shows high concordance with conventional autopsy for skeletal and internal trauma, but cannot replace toxicological and histopathological examination. Neither the Bharatiya Nagarik Suraksha Sanhita nor the Bharatiya Sakshya Adhiniyam recognises virtopsy independently, although imaging is admissible as expert evidence. Thus, formal legal recognition, standardised protocols, pilot centres and training in forensic radiology are required before virtopsy can be adopted in India.

Keywords: Digital autopsy, post-mortem, traditional autopsy

Background:
Autopsy, derived from the Greek word "autopsia," meaning "to see for oneself," has long been a cornerstone of forensic medicine and legal investigation **[1]**. It serves as a critical tool for determining the cause, manner and circumstances of death, providing essential evidence for civil and medico legal cases **[2]**. However, conventional autopsy techniques, which rely on invasive dissection, often face significant resistance due to cultural, religious, ethical and emotional factors, as well as the risk of biohazard exposure to forensic personnel **[3]**. In recent decades, advances in imaging technology have introduced a novel, minimally invasive alternative, virtual autopsy technique, also known as virtopsy **[4]**. This technique employs radiological modalities, such as computed tomography (CT), magnetic resonance imaging (MRI) and three-dimensional surface scanning, to visualize internal structures without the need for extensive dissection **[1, 2]**. Virtual autopsy was pioneered in the late 1990s in Switzerland, where Richard Dirnhofer initiated the Virtopsy Project at the Institute of Forensic Medicine, University of Bern, and Thali and co-workers developed it into an established imaging-based forensic method **[3]**. Since then, it has gained global recognition as an adjunct or alternative to traditional autopsies, especially in medico legal, disaster victim identification and mass casualty scenarios **[5]**. The advantages of virtopsy include its non-invasiveness, digital documentation, preservation of cultural and religious integrity and the ability to store and reanalyze data indefinitely **[4, 6]**. Furthermore, it minimizes human error and subjective interpretation, allowing multidisciplinary collaboration between radiologists, forensic experts and pathologists **[6]**. Indian forensic medicine has developed its own statutory and institutional traditions over more than a century, and any new investigative modality must be accommodated within that established framework **[7]**. In India, where religious sentiments and familial objections often impede conventional post-mortem examinations, virtual autopsies are promising **[8]**. Despite its technical sophistication and ethical appeal, its implementation in the Indian medico legal framework remains limited **[9]**. The legal acceptance of virtual autopsy in India is currently ambiguous, as no specific statutory provisions explicitly recognize digital imaging as an alternative to dissection under the existing laws. Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023 mandate a postmortem examination by a qualified medical practitioner for unnatural or suspicious deaths **[10]**. However, these provisions were drafted when imaging-based technologies were nonexistent, thereby creating a legislative vacuum for modern innovations such as virtopsy **[10]**. While a few Indian institutions, such as the All India Institute of Medical Sciences (AIIMS), New Delhi, the Post Graduate Institute of Medical Education and Research (PGIMER) and Chandigarh, have conducted pilot studies on post-mortem imaging, the results have yet to influence national policy or judicial acceptance **[8]**. Courts in India continue to rely primarily on traditional autopsy reports as admissible evidence, as defined under the Bharatiya Sakshya Adhiniyam 2023 (BSA) and validated through expert testimony **[9]**. Nonetheless, the increasing global precedent for virtual autopsies has prompted discussions among forensic professionals, legal scholars and policymakers regarding their potential integration into the Indian judicial and investigative systems **[8, 9]**. From technological and ethical standpoints, virtual autopsy offers several advantages that align with the constitutional values of human dignity and privacy **[11]**. This is especially relevant in cases involving high-profile deaths, custodial deaths and situations in which traditional autopsies may compromise evidentiary integrity **[12]**. Moreover, it offers an opportunity for the digital archiving of forensic data, facilitating transparency, reproducibility and global collaboration in forensic research **[11, 13]**. However, barriers such as high equipment costs, lack of trained forensic radiologists, inadequate infrastructure and absence of standardized legal protocols hinder its widespread adoption in India. Additionally, the absence of explicit legal validation raises questions regarding the admissibility of virtopsy findings in the courts of law, necessitating judicial and legislative clarity **[14]**. Therefore, it is of interest to evaluate the current legal status of virtual autopsy in India and to show the statutory, procedural and infrastructural changes required for its formal recognition within the medico-legal system.

Diagnostic performance of post-mortem imaging:
The present review highlights that virtual autopsy (virtopsy) represents a promising adjunct to conventional medico-legal postmortem examinations in India, offering significant advantages in terms of objectivity, documentation and cultural acceptability. The main findings suggest that postmortem computed tomography (PMCT) and magnetic resonance imaging (PM-MRI) can detect a wide spectrum of fatal injuries, such as intracranial hemorrhage, fractures, air embolism and foreign bodies, with high accuracy, comparable to or exceeding

that of traditional autopsy in certain anatomical regions **[15, 16]**. Studies conducted in Europe and Japan have showed strong concordance between virtopsy and conventional dissection in determining the cause of death, particularly trauma and firearm fatalities **[17, 18]**. Although limited, Indian studies have shown similar feasibility and diagnostic value when used in academic tertiary centers **[19, 20]**. A recent systematic review of medico-legal applications reported that post-mortem imaging achieves high agreement with conventional autopsy for skeletal trauma, intracranial haemorrhage and retained foreign bodies, while performing less well for soft-tissue, vascular and infective pathology **[21]**. Modality-specific work has extended this to particular causes of death, including the characteristic imaging features described for drowning **[22]**, and three-dimensional reconstruction has been used to confirm normal fetal cardiac anatomy in the first trimester, indicating the level of anatomical resolution now achievable in small specimens **[23]**.

Legal status and admissibility in India:
The current legal framework in India, which is primarily governed by the BNSS and BSA, does not explicitly recognize post-mortem imaging as a standalone medico-legal tool; although courts have accepted radiological findings as admissible expert evidence in select cases **[24].**

Advantages of virtual autopsy:
Virtopsy provides unique advantages, including non-invasiveness, permanent 3D record generation and reduced distress among relatives from different cultural and religious backgrounds **[25].** High-resolution imaging data preserve the integrity for review, teleconsultation and judicial demonstration, which is particularly useful when re-examination or re-investigation is ordered. Moreover, the digital storage of post-mortem imaging contributes to enhanced transparency and educational value in forensic training **[26, 27].**

Strength and limitations of the available evidence:
The main strength of the current evidence lies in its consistent demonstration of its technical feasibility, reproducibility and ethical acceptance. However, the level of evidence remains moderate because of the small sample sizes, lack of randomization and heterogeneous methodology used in published reports **[28]**. Most of the available studies were observational feasibility reports, rather than randomized or comparative diagnostic trials. Heterogeneity in scanner type, an image acquisition protocol and interpretation criterion has restricted direct comparison. Moreover, many Indian studies lack detailed legal analysis or standardized criteria for the "admissibility" of virtopsy evidence in court **[29]**. Restricted access to non-English literature, regional government reports and proprietary legal databases is an additional constraint on the available evidence. Comparable concerns have been raised in perinatal practice, where virtual autopsy is increasingly offered to families but imaging protocols, reporting formats and operator training remains unstandardised **[30]**.

Strengthening admissibility of virtopsy evidence:
From a legal-forensic perspective, the major challenge remains the formal recognition and integration of virtopsy findings into statutory and procedural frameworks. To strengthen admissibility, standardized reporting formats co-signed by forensic pathologists and radiologists must be established. Such collaborative documentation aligns with the principle of "expert opinion under section 39 of BSA 2023," providing multidisciplinary validation **[31]**. Additionally, periodic judicial sensitization and interdepartmental guidelines from the Ministry of Health and Family Welfare (MoHFW) or the National Medical Commission (NMC) would help operationalize this emerging domain within medico-legal workflows. Experience elsewhere indicates that accreditation of the imaging facility it is an important step: a survey of forensic virtual autopsy laboratories found wide variation in construction, staffing and quality systems, and argued for formal laboratory accreditation as a precondition of evidentiary reliability **[32]**. Legal commentary has similarly emphasised that admissibility will ultimately turn on showing that the imaging record is complete, tamper-evident and interpretable by an appropriately qualified expert **[33].**

Practical implications and future directions:
In the short term, pilot centers equipped with CT or MRI facilities in medical colleges could serve as demonstration units for postmortem imaging, with standard operating procedures defining the imaging parameters, documentation and data security. In the long term, a national virtopsy registry integrating anonymized post-mortem imaging data could enhance research capacity and enable the training of forensic radiologists **[13].** The next step for researchers involves multicenter prospective studies evaluating diagnostic concordance between PMCT/PM-MRI and traditional autopsy across various causes of death, with cost-effectiveness and turnaround time as secondary outcomes **[34, 35 and 36].** Additionally, socio-ethical research exploring public perceptions and cultural acceptance can inform policy formulation.

Conclusion:
Virtual autopsy is a reliable adjunct to conventional autopsy, with established diagnostic value in trauma, firearm and decomposed cases. Its legal status in India remains undefined, as neither the BNSS nor the BSA recognises post-mortem imaging as an independent medico-legal tool. Statutory recognition, standardised national guidelines and judicial sensitization are required before virtopsy can enter routine practice.

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