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Exploring the Efficacy of Virtual Autopsy vs Scientific Conventional Autopsy: A Comparative Study in A Tertiary Care Hospital

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Abstract

Purpose: Virtual autopsy, or "virtopsy", is a non-invasive autopsy technique using advanced imaging modalities such as CT and MRI to evaluate internal and external body structures. It serves as a viable alternative to scientific conventional autopsy, especially in cases with cultural, religious, or emotional objections to internal dissection. It also serves a material evidence for production in the court even after disposal of the body. This study is aimed to compare the findings of virtual autopsy with those of scientific conventional autopsy and assess the advantages and limitations of each method.

Materials and Methods: A cross-sectional study was conducted over 12 months (December 2023–December 2024) at MIMS, Mandya, involving 30 deceased individuals referred for postmortem CT. All cases underwent whole-body CT scanning, followed by scientific conventional autopsy using standard dissection techniques. Data on age, sex, history, imaging findings, autopsy results, and cause of death were collected and analyzed.

Results: The study population included 30 deceased individuals—15 males and 15 females—distributed across three age groups, with the majority (50%) aged 21–40 years. Virtual autopsy demonstrated nearly 100% sensitivity in detecting fractures, dislocations, and pathological gas collections, and proved more accurate in subcutaneous pneumatosis. Intracranial hemorrhages were identified with 100% sensitivity and specificity by both modalities. However, scientific conventional autopsy was superior in identifying atheromatous arterial changes, external injuries like abrasions and ligature marks. Scientific conventional autopsy is also advantageous in microscopic and toxicological analyses as the samples may be collected and sent.

Conclusion: Virtual autopsy is a valuable adjunct to scientific conventional autopsy, offering high sensitivity in detecting internal injuries and preserving the integrity of the body. While it cannot fully replace scientific conventional autopsy due to limitations in histological and toxicological analysis, it significantly enhances postmortem diagnostics and is very much useful in cases with restricted autopsy consent.

Keywords: Computed Tomography Virtual Autopsy, MRI, Non-Invasive

Introduction

Virtual autopsy uses postmortem CT to provide non-invasive alternative to scientific conventional autopsy. recent advancements in medical imaging and technology have introduced virtual autopsy, also known as "virtopsy", as a non-invasive alternative to scientific conventional autopsy methods. Virtual autopsy utilizes cross sectional imaging techniques such as CT (computed tomography) and MRI (magnetic resonance imaging) to visualize and assess the body externally and internally, without the need for invasive procedures.[1] Its main goal is to supplement and eventually replace scientific conventional autopsies, in cases where internal dissection is met with emotional, cultural or religious objections.[1,2] It is primarily performed in cases where subtle fractures, air embolism, pneumothorax/ spinal cord contusions are suspected out/ if there is a discrepancy between the reported history and external injuries / suspicious circumstances are suspected. The findings of this study may contribute to the growing body of research on virtopsy and inform the development of guidelines and protocols for its use in forensic death investigation.

Aim and objectives of the study: to compare the results of virtual autopsy with the findings of scientific conventional autopsy and to analyze the advantages and disadvantages of one over the other.

Materials and Methods

This cross-sectional retrospective study was conducted over a 12-month period (December 2023 to December 2024) at the Department of Radiology, MIMS Mandya, focusing on deceased individuals referred for postmortem CT (PMCT). Institutional ethics committee approval was obtained on February 5th 2025.

Sample size: 30.

Inclusion criteria: Deceased bodies of varying ages with doubtful circumstantial evidence regarding the manner and cause of death or if there is a discrepancy between external findings and the history given.

Exclusion criteria: Deceased bodies with clear circumstantial evidence regarding the manner and cause of death and where the external findings are consistent with the reported history, all poisonous consumption cases and sudden natural deaths.

The sampling technique employed was convenience sampling. Out of 550 cases done during the study period in the institute 30 cases are included after taking into account of inclusion and exclusion criteria. All cases were scanned in the supine position with head-first entry. Whole-body scans were performed using a soft tissue window (WW-300, WL-40), and head scans were conducted with a brain window (WW-80, WL-35). Following each scan, the CT couch was disinfected using sterilium, and the CT room was fumigated. Images were acquired using a uCT 780 scanner (160-slice) with multiplanar and 3D reconstruction capabilities. Scientific conventional autopsies were performed following standard "I" incisions and Virchow's method in most of the cases, en bloc dissection and letulle's method for a few cases. Findings from scientific conventional autopsies were collected from the forensic medicine department. Key study variables included age, sex, history, virtual autopsy findings, scientific conventional autopsy findings, and cause of death. These variables were carefully compared and correlated to assess the performance and reliability of virtual autopsy relative to scientific conventional autopsy.

Observation and Results

Demographic Data

The study was performed on 30 deceases bodies, evenly distributed between male (15 cases, 50%) and female (15 cases, 50%) subjects. Age-wise distribution was as follows: 6 cases (20%) in the 1-20 years age group, 15 cases (50%) in the 21-40 years age group, and 9 cases (30%) in the 41-60 years age group.(table 1)

Comparison of Findings

A comparative analysis of findings between virtual autopsy and scientific conventional autopsy revealed distinct patterns (Figure 2). Virtual autopsy demonstrated superior performance in identifying pathological gas collections, detecting 28 cases compared to only 2 cases by scientific conventional autopsy. Case 4 shows air in the great vessels which cannot be detected in the scientific conventional autopsy. Similarly, intracranial hemorrhages were identified with 100% sensitivity and specificity by both modalities, reflecting perfect agreement. Diffuse SAH in case 1 and case 4.

The sensitivity of the PMCT in detecting the fracture was 100% (confidence interval (CI) = 2.5–100%) Fractures and dislocations were identified more frequently in virtual autopsies (8 cases) compared to scientific conventional autopsies (4 cases).Example – case 1 and case 2.

In contrast, atheromatous changes in arteries were exclusively identified by scientific conventional autopsy in 22 cases, with virtual autopsy failing to detect these findings, resulting in a sensitivity of 0% and an accuracy of 70.0%. Ligature marks and surface contusions were more frequently detected by scientific conventional autopsy (9 cases) than virtual autopsy (7 cases), with a moderate sensitivity (77.8%) and accuracy (66.7%) for virtual autopsy in detecting these features. Case 3 shows ligature mark in both scientific conventional and virtual autopsy. Table 2 shows diagnostic performance of virtual autopsy compared to scientific conventional autopsy.

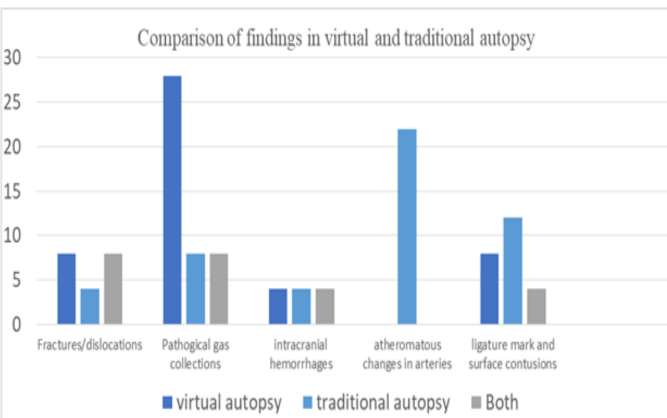
Table 1: Age and sex distribution

		Cases	Percentage
Age	1-20	6	20%
	21-40	15	50%
	41-60	9	30%
Sex	M	15	50%
	F	15	50%

Table 2: Diagnostic performance of virtual autopsy compared to scientific conventional autopsy

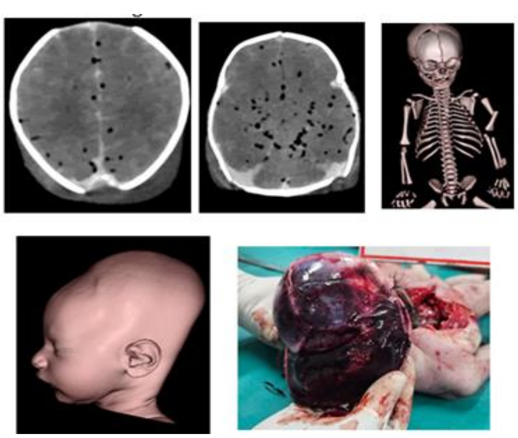
Finding	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Fractures/dislocations	100	100	100	100	100
Pathological gas collections	100	68.2	84.8	100	86.7
Intracranial hemorrhages	100	100	100	100	100
Atheromatous changes in arteries	0	100	0	70.0	70.0
Ligature marks and surface contusions	77.8	55.6	63.6	71.4	66.7

Figure 1: Comparison of findings in virtual and scientific conventional autopsy



Representative Cases

Figure 2:



Case 1: A 1day old male baby dead after normal vaginal delivery shows pneumocephalus, comminuted fracture of shaft of humerus, SAH.

3D reconstructed image shows caput succedaneum confirmed by autopsy photograph

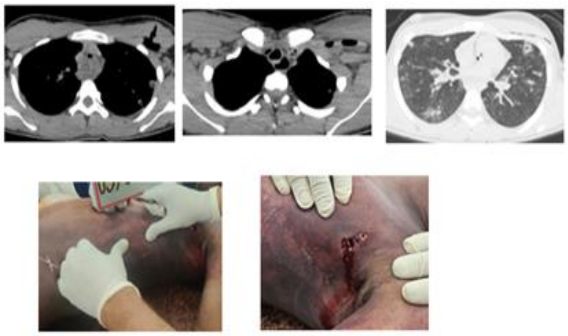
Figure 3:

Case 2: A 14 year old female (POCSO and alleged h/o rape BNS 63, IPC 375) with a/h/o hanging Sagittal CT of the pelvis showed gravid uterus with gestation corresponding to ~9-10 weeks.

Autopsy photographs shows uterus with gestation sac.

3D reconstructed image shows ligature mark in the neck confirmed by the autopsy photograph

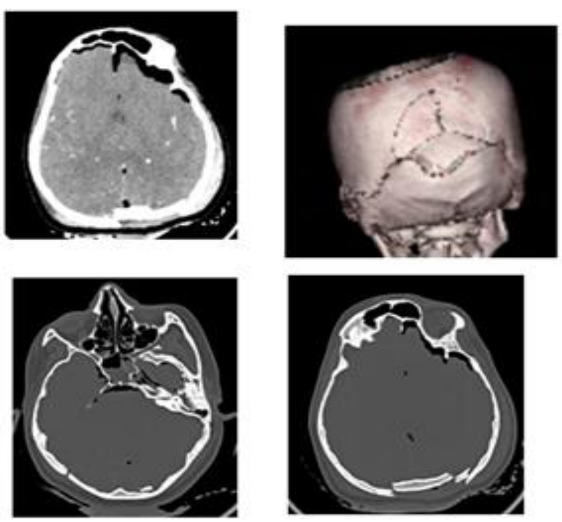
Figure 4:



Case 3: A 18yr old male with a/h/o stab injury with quadriparesis with features of air embolism, septic emboli in bilateral lung fields.

Autopsy photograph shows features of DIC with a stab wound in the left pectoral region

Figure 5:



Case 4: A 20 yr old female with a h/o fall from bike showed pneumocephalus, diffuse SAHand depressed occipital bone fracture, petrous apex fracture.

Discussion

Virtual autopsy, also referred to as *virtopsy*, is a non-invasive postmortem examination technique that employs advanced imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), and in some cases, postmortem angiography, to assess both internal and external structures of the body without the need for scientific conventional dissection. CT offers several advantages, including rapid image acquisition, 3D reconstruction capability, identifying fractures and subcutaneous pneumatosis making it particularly suitable for forensic applications. MRI is better in soft tissue resolution. MRI was not performed in this study due to its longer scan times and associated logistical constraints.[1,3]

Scientific conventional autopsy involves a thorough external examination, followed by internal dissection, and is often complemented by ancillary investigations such as histopathological, toxicological, and microbiological analyses. The internal examination can be performed using one of several established dissection methods, including Virchow’s method, where organs are removed and examined individually, is the most commonly used in our institute. It allows for easy handling and detailed organ-specific pathology but may disturb anatomical relationships[5]

The other methods used in few cases are Letulle’s method, used selectively involves en bloc removal of thoracic, cervical, abdominal, and pelvic organs preserving organ relationships, making it particularly useful in pediatric and cardiovascular autopsies. Ghon’s method removes thoracic, cervical, and abdominal organs in blocks, balancing anatomical integrity and ease of dissection. Rokitansky’s technique emphasizes in situ dissection, suitable for infectious cases or when minimal organ manipulation is preferred[5].

A multi-detector computed tomography (MDCT) scanner is essential for performing virtual autopsies, with a preference for systems of 64-slice or higher (e.g., 128- or 160-slice scanners). 160-slice scanner is used in our institute. These scanners provide high-resolution volumetric data and allow for rapid acquisition of whole-body images, significantly reducing scan times and minimizing motion-related artifacts, even in postmortem cases[6,7]. The recommended scan range extends from head to toe to ensure comprehensive evaluation. Repeat scan acquisition of the head in brain window (WW 80/WL35) helps in evaluating fractures, intracranial hemorrhages and cerebral edema. Slice thickness should ideally range from 0.5 to 1.25 mm, allowing for detailed multiplanar reconstruction (MPR) and accurate 3D rendering of anatomical structures[6,18]. Scan pitch should be maintained between 0.8 and 1.2, while tube voltage typically ranges from 120 to 140 kVp, and tube current is adjusted as needed, generally falling within the 200–300 mA range[5]. Specific window settings are critical for optimal visualization of postmortem changes: the bone window (WW 2000 / WL 500) enhances fracture detection, the soft tissue window (WW 300 / WL 40) is suited for identifying hemorrhages and organ changes, and the brain window (WW 80 / WL 35) is essential for evaluating intracranial hemorrhages and cerebral edema [18]. These technical parameters collectively ensure that CT imaging provides high diagnostic accuracy for a wide range of postmortem findings, including skeletal injuries, gas collections, and soft tissue pathology[7,18].

After each postmortem scan, the CT couch surface and gantry are thoroughly wiped and disinfected using appropriate alcohol-based disinfectants such as Sterillium or quaternary ammonium compounds. In cases involving advanced decomposition or biohazard risk (e.g., suspected infectious disease or blood leakage), the entire CT room may be fumigated using formaldehyde, hydrogen peroxide vapor, or other approved fumigants. This is especially critical in hospital-based imaging departments where both living and deceased patients are scanned[5].

In this study, virtual autopsy identified more fractures and dislocations compared to scientific conventional autopsy with 100% sensitivity and specificity consistent with the observations by Dirnhofer et al.[1] and Ma et al.[3]. These findings highlight the superior capability of PMCT in detecting skeletal injuries, especially in trauma cases[6].

In this study virtual autopsy was helpful in detecting subtle fractures, fractures of the base of the skull, air embolism, pneumothorax, and spinal cord injuries, where scientific conventional autopsy may overlook critical findings[3,4]. It was able to detect minimal traumatic effusions in concealed/non approachable areas of regular autopsy.

Pathological gas collections were more frequently identified and had 100% accuracy via virtual autopsy in this study, corroborating previous research demonstrating CT's sensitivity in detecting gas embolism and decomposition changes[8,9]. This enhanced visualization is crucial in distinguishing postmortem artifacts from true antemortem pathology [10].

However, atheromatous changes in arteries were predominantly observed through scientific conventional autopsy, reflecting the current limitations of imaging in evaluating soft tissue and vascular pathologies[11]. Similar challenges have been documented by Haas et al.[4] and Grabherr et al.[12], who underscored the limitations of virtual autopsy in identifying subtle vascular diseases. Additionally, ligature marks and surface contusions were better appreciated during scientific conventional autopsy having higher sensitivity compared to virtual autopsy, echoing findings by Wichmann et al.[13] that PMCT is less effective for external soft tissue examination.

Virtual autopsy provides a permanent digital record, enabling review and second opinions, and is more acceptable in certain religious or cultural contexts where scientific conventional autopsy may face resistance[14,15]. The reduced risk of infection transmission during imaging-based autopsy has also been emphasized in contemporary forensic practice, as seen in the work by O'Donnell and Woodford[16]. Furthermore, 3D reconstructions from virtual autopsy enhance visualization, offering a clearer understanding of complex injuries[17].

Virtual autopsy, particularly through postmortem computed tomography (PMCT), has become an invaluable tool in the forensic evaluation of ballistic injuries. It enables accurate localization of bullets, pellets, and metallic fragments within the body, often identifying them in complex or deep anatomical regions where conventional dissection may be limited. PMCT also facilitates the reconstruction of wound trajectories by providing multiplanar and 3D visualizations that can trace the bullet's path, direction, and angle of entry or exit. This is especially useful in determining the range of fire and reconstructing shooting scenarios. Additionally, CT imaging clearly depicts skeletal injuries such as bone fractures and fragmentation, offering superior detail compared to scientific conventional autopsy in certain trauma contexts. Another advantage lies in its non-invasive nature, which preserves the integrity of the body and allows for repeat analysis or digital documentation for legal purposes. Moreover, the information obtained from virtual autopsy can guide scientific conventional autopsy by highlighting areas that warrant focused examination. These features make virtual autopsy a powerful adjunct in forensic investigations involving gunshot wounds and ballistic trauma [18,19].

Incidental findings and pre-existing medical conditions that may not be directly related to the fatal event like undiagnosed tumors, vascular anomalies, degenerative diseases, organ pathologies, or calcified plaques in arteries, offer valuable insights into the decedent's overall health status. Such findings are crucial in both forensic and clinical autopsy contexts, especially when the death is sudden or unexplained, or when medical history is incomplete. The non-invasive nature of virtual autopsy preserves internal structures, allowing for detailed evaluation of chronic diseases that may have contributed to morbidity[20].

Contrast-enhanced virtual autopsy, also known as postmortem CT angiography (PMCTA), significantly enhances the diagnostic capability of standard virtual autopsy by allowing detailed visualization of the vascular system. It is particularly useful in detecting vascular injuries, such as hemorrhage, aneurysms, or coronary artery blockages, which may be missed on non-contrast imaging. PMCTA can also help assess organ perfusion, identify sources of bleeding, and detect thromboembolic events, making it highly valuable in trauma and cardiovascular-related deaths. However, this technique was not performed in our institute due to the absence of specialized equipment, including heart-lung perfusion machines and angiographic pump systems, which are essential for effective postmortem contrast injection and circulation [21].

The findings from this study support that virtual autopsy is particularly effective in trauma cases and when external injuries are minimal or concealed. However, scientific conventional autopsy remains indispensable in evaluating vascular diseases and external injuries. A multidisciplinary approach integrating both methods can therefore maximize diagnostic accuracy and address the limitations of each modality.

Further research in virtual autopsy is required to address its current limitations and improve its reliability as a potential substitute for scientific conventional autopsy in both clinical and forensic settings. Key areas include the standardization of imaging protocols, especially for postmortem CT and MRI, to ensure consistent diagnostic accuracy across institutions[22]. Development and validation of postmortem contrast-enhanced techniques such as PMCT angiography are needed to enhance vascular assessment, particularly in cases of sudden cardiac death or internal hemorrhage[23]. Integration of artificial intelligence and automated detection tools could assist in identifying subtle pathologies, reducing operator dependency, and streamlining interpretation[24]. Additionally, more comparative studies with larger sample sizes are needed to statistically validate virtual autopsy findings against gold-standard scientific conventional autopsy results. Legal recognition of virtual autopsy findings also requires more interdisciplinary research involving radiologists, pathologists, legal experts, and ethicists to ensure admissibility in court and public trust [25].

Conclusion

Post mortem CT-based virtual autopsy offers high sensitivity in detecting fractures, pneumatosis, body cavity lesions and provides diagnostic information regarding fractures or lung contusions. Virtual autopsy demonstrated superior performance in identifying pathological gas collections, subtle skeletal fractures, and intracranial hemorrhages, establishing its strength in trauma-related cases and certain internal findings. However, scientific conventional autopsy is irreplaceable in detecting atheromatous vascular changes and superficial soft tissue injuries such as ligature marks and contusions, which remain beyond the current resolution capabilities of virtual autopsy. It adds as ancillary documentary medical evidence that would support the gross autopsy findings. Nondestructive to the corpse and does not affect the morphology of original injuries and adjacent structures. Post processing techniques may enhance its utility in courtroom settings.

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