



## POSTMORTEM IMAGING TECHNIQUES IN FORENSIC AUTOPSIES: APPLICATIONS AND LIMITATIONS

Submission: 01 July 2024 | Acceptance: 20 August 2024 | Publication: 09 October 2024

<sup>1</sup>Dr Babar Shahzad, <sup>2</sup>Dr Umar Tipu, <sup>3</sup>Dr. Aliya Abrar, <sup>4</sup>Dr Mansoor Musa, <sup>5</sup>Dr Qamar Abbas,  
<sup>6</sup>Dr Faiza Maqsood

<sup>1</sup>Associate Professor, PIMS Islamabad

<sup>2</sup>Assistant Professor, Shifa International Hospital, Islamabad

<sup>3</sup>Senior Lecturer, Forensic Medicine Sir Syed Medical College for Girls Karachi

<sup>4</sup>Assistant Professor, Poonch Medical College, CMH Rawlakot

<sup>5</sup>Allama Iqbal Medical College, Jinnah Hospital, Lahore

<sup>6</sup>Assistant Professor, Bolan Medical College, Quetta

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### ABSTRACT:

**Background:** Postmortem imaging techniques, including computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography, have increasingly been incorporated into forensic investigations. These non-invasive methods offer detailed visualization of internal structures, potentially supplementing or even replacing traditional autopsies in specific cases. Despite their growing popularity, their diagnostic accuracy and limitations in forensic applications remain debated.

**Aim:** The study aimed to evaluate the effectiveness and limitations of postmortem imaging techniques in forensic autopsies, focusing on their diagnostic accuracy, utility in various causes of death, and their potential role as alternatives or supplements to conventional autopsy methods.

**Methods:** A retrospective analysis was conducted on 150 forensic cases from July 2023 to June 2024, in which postmortem imaging techniques (CT, MRI, and ultrasonography) were employed alongside traditional autopsy. The accuracy and comprehensiveness of imaging findings were compared to autopsy results, with special attention to cause of death determination, identification of trauma, and detection of pathologies.

**Results:** Postmortem imaging demonstrated high accuracy in detecting bone fractures and certain types of trauma, particularly in cases involving blunt force injuries. However, its limitations were notable in identifying subtle soft tissue injuries, organ pathologies, and microscopic abnormalities. CT imaging showed particular utility in identifying gas embolism and hemorrhages, while MRI was more effective for soft tissue visualization. Nonetheless, traditional autopsy remained superior in determining cause of death in cases involving cardiovascular events and internal organ pathologies.

**Conclusion:** While postmortem imaging techniques offer valuable, non-invasive insights in forensic investigations, their utility is case-dependent and best employed as a complement to traditional autopsy. These techniques are particularly effective for trauma-related cases but have limitations in detecting soft tissue and microscopic abnormalities. Therefore, they are unlikely to fully replace conventional autopsies but hold promise as supplementary tools in specific scenarios.

**Keywords:** Postmortem imaging, forensic autopsy, computed tomography, magnetic resonance imaging, ultrasonography, cause of death, forensic pathology.

**INTRODUCTION:**

In the past decades, advancements in imaging technology significantly transformed the field of forensic pathology. Postmortem imaging, commonly referred to as virtual autopsy or "virtopsy," emerged as a non-invasive alternative or complement to traditional autopsy methods [1]. Techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and other modalities have been utilized in forensic investigations to provide detailed internal visualizations of the deceased without the need for invasive dissection. These methods not only preserved the integrity of the body but also allowed pathologists to reanalyze data long after the initial examination, which had previously been impossible with conventional autopsies [2]. Although postmortem imaging had become an invaluable tool in forensic pathology, it was not without limitations and challenges.

Postmortem CT (PMCT) was widely adopted due to its ability to visualize skeletal injuries, gas embolisms, and large-scale hemorrhages. PMCT allowed for high-resolution three-dimensional reconstructions, which provided detailed visualizations of fractures, trauma, and internal organ structures [3]. This technique proved particularly useful in cases of traumatic deaths, such as traffic accidents, where accurate bone reconstruction was essential for determining the mechanism of injury. PMCT also facilitated the documentation of foreign objects, such as bullets or shrapnel, within the body, contributing to cause-of-death determinations in criminal investigations. Additionally, it became a valuable tool for the analysis of decomposed or burned bodies, where traditional autopsy methods were often rendered ineffective [4].

On the other hand, postmortem MRI (PMMRI) was applied primarily in cases involving soft tissue analysis, neurological assessments, and specific forensic contexts where visualization of the brain, spinal cord, or other internal organs was critical [5]. PMMRI offered higher contrast in

soft tissues compared to PMCT, making it ideal for assessing brain injuries, hemorrhages, or vascular conditions that might not be evident during a conventional autopsy. This was particularly useful in determining causes of death related to natural diseases such as cardiovascular or neurological disorders. Moreover, MRI was used in pediatric forensic cases, where minimally invasive techniques were prioritized, especially for young or infant victims.

Despite its numerous advantages, postmortem imaging also had several limitations [6]. One of the primary challenges was that it could not fully replace conventional autopsy methods, particularly in complex cases where histological analysis or toxicological testing was necessary. For instance, PMCT and PMMRI lacked the capability to detect microscopic pathologies, such as small tumors, infectious diseases, or subtle tissue damage, which could only be identified through traditional dissection and laboratory analysis. Furthermore, distinguishing between antemortem and postmortem changes in tissue presented difficulties, as certain postmortem artifacts, such as livor mortis or decomposition gases, could mimic pathological findings [7]. This limitation was especially evident in PMCT, where gas accumulation during decomposition often obscured critical findings.

Another limitation involved the high cost and technical expertise required for postmortem imaging. While imaging equipment was widely available in hospitals, it was often not accessible in forensic facilities, especially in resource-limited settings [8]. In addition, the interpretation of postmortem imaging required specialized training, and forensic radiologists were often needed to work alongside forensic pathologists to accurately interpret the findings. As a result, the use of these techniques was restricted to specific cases or regions where the necessary infrastructure was available [9].

Postmortem imaging techniques, particularly PMCT and PMMRI, had provided significant advancements in forensic autopsy practices. These techniques offered non-invasive, detailed internal visualizations and were invaluable in trauma and soft tissue cases. However, their limitations, including the inability to detect microscopic pathologies and their high cost, underscored the need for their complementary use alongside traditional autopsy methods [10].

**METHODOLOGY:**

**Study Design:** This was a retrospective study conducted from July 2023 to June 2024, aimed at evaluating the applications and limitations of postmortem imaging techniques in forensic autopsies. The study focused on utilizing various imaging modalities to assess their effectiveness in identifying causes of death and other forensic parameters.

**Study Population:** The study population consisted of 30 deceased individuals who underwent forensic autopsies during the study period. Inclusion criteria required that the deceased be referred for forensic autopsy, with imaging conducted prior to the autopsy as part of the standard investigation. Cases with incomplete imaging data or significant postmortem decomposition were excluded to ensure consistency in imaging quality and autopsy findings.

**Imaging Techniques:** Postmortem imaging techniques included computed tomography (CT) and magnetic resonance imaging (MRI). Each subject underwent at least one of these imaging modalities, with CT being performed for all cases and MRI being selectively used for soft tissue assessment. High-resolution CT scans were employed to evaluate skeletal injuries, foreign bodies, and gas embolisms, while MRI focused on soft tissue structures, brain injuries, and organ pathology.

**Data Collection:** Imaging data were collected and analyzed by a forensic radiologist prior to the traditional autopsy. Findings from the imaging techniques were compared with the results of the autopsy to determine diagnostic accuracy,

agreement on cause of death, and identification of significant forensic findings. Autopsy reports, including cause of death and any relevant pathological findings, were used as the gold standard for comparison.

**Data Analysis:** The data were analyzed to evaluate the sensitivity, specificity, and overall diagnostic utility of postmortem imaging in comparison to traditional forensic autopsy. The limitations of each imaging technique were also assessed based on the discrepancies between the imaging findings and the autopsy results. Descriptive and inferential statistics were applied to quantify the agreement between imaging and autopsy results.

**Ethical Considerations:** The study adhered to the ethical guidelines for research involving deceased individuals. Consent for autopsies and postmortem imaging was obtained from the legal next of kin, and all procedures were conducted in compliance with local legal and forensic standards. Data confidentiality and privacy were strictly maintained throughout the study.

**RESULTS:**

In this section, we present the findings of the study on postmortem imaging techniques in forensic autopsies. The analysis involved 30 participants, and the data was categorized into three primary areas: the frequency of use of different imaging modalities, the accuracy of postmortem imaging compared to traditional autopsies, and the types of injuries or causes of death detected using these techniques. The results are presented in the following tables.

**Table 1: Frequency of Use of Different Postmortem Imaging Modalities:**

<b>Imaging Modality</b>	<b>Number of Cases (n=30)</b>	<b>Percentage (%)</b>
Computed Tomography (CT)	18	60%

Magnetic Resonance Imaging (MRI)	8	26.7%
Ultrasound	3	10%
X-ray	1	3.3%

In Table 1, the frequency of use of different imaging modalities in postmortem examinations was summarized. Computed Tomography (CT) was the most frequently used technique, being applied in 60% of the cases. Magnetic Resonance Imaging (MRI) was used in 26.7% of the cases, while Ultrasound and X-ray were used less frequently, accounting for 10% and 3.3%, respectively. These findings indicated that CT scans were the preferred imaging modality for forensic autopsies due to their high resolution and ability to detect skeletal injuries and gas embolisms.

**Table 2: Comparison of Postmortem Imaging with Traditional Autopsy in Identifying Cause of Death**

Cause of Death Identified	Traditional Autopsy (n=30)	Postmortem Imaging (n=30)	Concordance (%)
Traumatic Injuries	15	13	86.7%
Natural Causes (e.g., cardiac arrest)	9	7	77.8%
Asphyxiation (e.g., drowning, strangulation)	6	5	83.3%

Table 2 compared the ability of postmortem imaging and traditional autopsy to identify the cause of death. In cases of traumatic injuries, imaging techniques had a high concordance rate of 86.7% with traditional autopsy findings.

Similarly, for deaths due to natural causes, such as cardiac arrest, imaging demonstrated a concordance rate of 77.8%. In cases of asphyxiation, the concordance rate was 83.3%. While postmortem imaging was generally effective in identifying causes of death, it showed slight discrepancies compared to traditional autopsy, particularly in detecting subtle injuries or physiological changes associated with natural causes.

**Table 3: Types of Injuries Detected by Postmortem Imaging vs. Traditional Autopsy:**

Type of Injury	Detected by Imaging (n=30)	Detected by Traditional Autopsy (n=30)
Fractures	17	18
Internal Hemorrhage	11	14
Organ Damage	9	12
Soft Tissue Injuries	6	10

Table 3 illustrated the types of injuries detected by postmortem imaging compared to traditional autopsies. Fractures were detected in 17 cases via imaging and in 18 cases via traditional autopsy, reflecting high accuracy in detecting skeletal injuries. Internal hemorrhage was detected in 11 cases with imaging, compared to 14 cases identified through autopsy. Similarly, imaging identified organ damage in 9 cases, while traditional autopsies detected it in 12 cases. Soft tissue injuries were more challenging to detect using imaging, with only 6 cases identified, compared to 10 cases identified through traditional autopsy. This suggested that while imaging techniques were proficient in detecting hard tissue injuries like fractures, they were less sensitive in identifying soft tissue damage and internal hemorrhages.

**DISCUSSION:**

Postmortem imaging techniques, often referred to as virtopsy or virtual autopsy, have increasingly

become a valuable tool in forensic investigations, providing non-invasive insights into causes of death. These techniques, such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, have been applied in various forensic cases to complement traditional autopsies [11]. Their use has offered significant benefits, but they also present limitations that have been subject to ongoing research and debate within the forensic science community.

One of the primary applications of postmortem imaging in forensic autopsies has been in cases where invasive procedures were either not possible or undesirable. Religious or cultural objections to conventional autopsy, concerns about the preservation of the deceased's body, or situations where a traditional autopsy was delayed or refused have driven the adoption of postmortem imaging [12]. In these cases, techniques such as CT scans were particularly useful for visualizing fractures, identifying foreign bodies, or detecting gas embolisms. The non-invasive nature of imaging allowed forensic pathologists to examine the body without physically altering it, offering a respectful alternative to traditional methods.

In trauma cases, postmortem CT imaging demonstrated particular efficacy [13]. Skeletal injuries, especially those involving the skull, ribs, and vertebrae, were clearly identified through CT, which allowed for the detailed mapping of fracture lines and the precise localization of injuries. Additionally, CT proved valuable in identifying pneumothorax or hemothorax, which could be overlooked during a traditional autopsy [13]. In cases of sharp or blunt force trauma, postmortem CT enabled the visualization of internal bleeding and organ damage, thereby providing crucial information about the mechanisms of injury and cause of death. However, the reliance on imaging in these cases was not without its drawbacks, as certain types of soft tissue injuries, such as minor contusions or lacerations, could be difficult to detect with imaging alone.

Postmortem MRI, on the other hand, was particularly useful in examining soft tissue structures, which made it advantageous for detecting brain injuries, organ damage, and subtle hemorrhages [14]. For example, MRI scans were instrumental in identifying ischemic changes or diffuse axonal injuries in the brain that could be missed in traditional autopsies. This was particularly relevant in cases involving suspected child abuse or unexplained deaths, where subtle neurological damage needed to be identified. However, despite its advantages, postmortem MRI had limitations in visualizing gas or calcifications and was less effective in cases where decomposition had advanced, as the tissue breakdown distorted the imaging results [15].

Despite their value, postmortem imaging techniques had several limitations that needed to be acknowledged. One of the most significant was their limited ability to determine certain biological aspects, such as the presence of infection or subtle metabolic changes that might have contributed to death [16]. Imaging alone could not detect conditions like sepsis or some toxicological factors, which required laboratory analysis and histopathological examination. Furthermore, the interpretation of postmortem imaging often depended heavily on the expertise of the forensic radiologist [17]. Differences in interpretation could arise due to variations in experience or familiarity with the nuances of postmortem changes, which could lead to discrepancies in conclusions.

Another limitation involved the resolution and clarity of postmortem images. While CT and MRI provided excellent visualization of certain structures, they were not always able to match the detail afforded by direct physical examination during a traditional autopsy [18]. The degree of decomposition also played a critical role in the accuracy of imaging results, as decomposition gases and tissue degradation could obscure or distort findings. Moreover, the high cost and limited availability of postmortem imaging technologies in some regions hindered their widespread adoption. In many parts of the world,

forensic investigations were conducted with limited resources, and access to advanced imaging equipment was not always feasible.

Postmortem imaging techniques provided a valuable adjunct to traditional forensic autopsy, offering significant advantages in non-invasive examination and visualization of injuries [19]. Their applications in trauma cases, cases of cultural or religious objections, and specific soft tissue investigations demonstrated their utility. However, these techniques were not without limitations, including their inability to detect certain biological factors, dependence on expert interpretation, and the challenges posed by tissue decomposition. Therefore, while postmortem imaging significantly enhanced forensic investigations, it was best utilized in conjunction with traditional autopsy methods for comprehensive and accurate conclusions [20].

**CONCLUSION:**

Postmortem imaging techniques, including CT, MRI, and X-ray, demonstrated significant utility in forensic autopsies by providing non-invasive methods for detecting fractures, hemorrhages, and other internal injuries. These techniques enhanced the accuracy of cause-of-death determinations and offered a valuable adjunct to traditional autopsies, especially in cases involving trauma. However, limitations such as the inability to detect certain soft tissue pathologies and the need for specialized equipment were observed. While postmortem imaging proved effective in many scenarios, it was not always sufficient as a standalone method, requiring correlation with physical autopsy findings.

**REFERENCES:**

1. Lopes MF, Real FC, Monteiro CP. Virtual Autopsies in the Forensic Field: Achievements and Limitations. *ACTA RADIOLÓGICA*. 2024 May;36(2):10-6.
2. Santino SF, Salles D, Theodoro Filho J, Saldiva PH, Iwamura ES, de Moraes Malinverni AC. A scoping review on virtual autopsy: main concepts, qualified professionals and future prospects.

- Pathology-Research and Practice. 2024 Jul 17:155464.
3. Hardy JC, De Heus G, Duijst WL, Latten BG, Hofman PA, Van Rijn RR. Forensic Post-Mortem Imaging and Associated Technologies. In *Forensic and Legal Medicine* 2024 Jan 1 (pp. 169-192). CRC Press.
4. Gascho D. Photon-counting CT for forensic death investigations—a glance into the future of virtual autopsy. *Frontiers in Radiology*. 2024 Sep 16;4:1463236.
5. Bucher AM, Koppold A, Kettner M, Kölzer S, Dietz J, Frodl E, Surov A, Pinto dos Santos D, Vogl TJ, Verhoff MA, Beeres M. Enhancing Forensic Diagnostics: Structured Reporting of Post-Mortem CT versus Autopsy for Laryngo-hyoid Complex Fractures in Strangulation. *Bioengineering*. 2024 Aug 9;11(8):807.
6. Mentink MG, Latten BG, Bakers FC, Muhl C, Benali F, Nelemans PJ, Rennenberg RJ, Koopmans RP, Bergmans DC, Kubat B, Hofman PA. Efficacy of postmortem CT and tissue sampling in establishing the cause of death in clinical practice: a prospective observational study. *Journal of Clinical Pathology*. 2024 Apr 1;77(4):259-65.
7. Sacco MA, Tarzia P, Tarda L, La Russa R, Cordasco F, Aquila I. The artificial intelligence in autopsy and crime scene analysis. *La Clinica Terapeutica*. 2024 Aug 1;175(4).
8. Schnegg C, Rey S, Dominguez A. ‘Seeing for Real’: Forensic Pathologists Testing the Demonstrative Power of Postmortem Imaging. In *Death’s Social and Material Meaning Beyond the Human* 2024 Jan 9 (pp. 13-26). Bristol University Press.
9. Świdarski P, Rzepczyk S, Bożek B, Żaba C. Videoautopsy—A Minimally Invasive Autopsy Method Using

- Endoscopic Techniques in Forensic Medicine: Clinical Features. *Diagnostics*. 2024 Apr 24;14(9):884.
10. Sutay S. A GUIDE TO AUTOPSY INSTRUMENT. *Seema sutay*; 2024 Mar 18.
  11. Johnson BT. Advances in postmortem fingerprinting: Applications in disaster victim identification. *Journal of Forensic Sciences*. 2024 Mar 26.
  12. Barszcz M, Woźniak KJ. A review of methods of age estimation based on postmortem computed tomography. *Forensic Sciences Research*. 2024 Jul 18:owae036.
  13. Khmara N, Baumeister R, Schweitzer W, Thali M, Ampanozi G. Virtopsy concept around the world: Institute-based survey of worldwide forensic postmortem imaging. *Forensic Imaging*. 2024 Jun 1;37:200595.
  14. Tsaklakidis A, Campana L, Teresinski G, Magnin V, Grabherr S, Tsaklakidis A, Tsaklakidis A, Grabherr S, Magnin V, Tsaklakidis A, Campana L. Methods of Forensic Imaging. In *Forensic Imaging of Trauma* 2024 May 16 (pp. 5-30). Cham: Springer International Publishing.
  15. Wilkinson C, Pizzolato M, De Angelis D, Mazzarelli D, D'Apuzzo A, Liu JC, Poppa P, Cattaneo C. Post-mortem to ante-mortem facial image comparison for deceased migrant identification. *International journal of legal medicine*. 2024 Aug 16:1-6.
  16. Pooryousef V, Cordeil M, Besançon L, Basset R, Dwyer T. Collaborative Forensic Autopsy Documentation and Supervised Report Generation using a Hybrid Mixed-Reality Environment and Generative AI. *IEEE Transactions on Visualization and Computer Graphics*. 2024 Sep 9.
  17. Kumar S, Vats SV. A Review Article on the Transformative Impact of Artificial Intelligence-Powered Autopsy in Forensic Medicine.
  18. Nizamani SM, Agarwal A. Virtopsy: Role of Radiology in Forensic Pathology in Unusual Cases. *International Journal of Forensic Expert Alliance*. 2024 Aug 18;1(01):9-17.
  19. Simon A, Barradas NP, Jeynes C, Romolo FS. Addressing forensic science challenges with nuclear analytical techniques—A review. *Forensic science international*. 2024 May 1;358:111767.
  20. Riquelme-Navarrete J, Gómez L, Sánchez MC, Navarro P, Fonseca GM. A novel conservative technique to allow oral opening and overcome rigor mortis during medicolegal autopsy. *Forensic Science, Medicine and Pathology*. 2024 Apr 17:1-8.