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Tracing the Trajectory: A New Era in Forensic Science: Case Report

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Abstract: ***Virtual autopsy, or virtopsy, represents a transformative shift in forensic pathology by replacing traditional invasive medicolegal autopsies with advanced imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), and 3D surface scanning. This non-invasive technique enables comprehensive visualization of internal structures, facilitating accurate documentation of injuries, pathologies, and foreign objects without compromising the integrity of the body. Particularly valuable in cases involving decomposed, mutilated, or culturally sensitive remains, virtual autopsy enhances diagnostic precision while respecting ethical and religious considerations. Its applications span forensic death investigations, trauma analysis, and medico-legal documentation, offering reproducible data for interdisciplinary collaboration and legal proceedings. Despite limitations in tactile feedback and histological sampling, virtual autopsy serves as a complementary tool to conventional autopsy, with growing potential in forensic neuropathology, mass disaster response, and digital archiving. Continued technological advancements and integration with histopathology and toxicology may further establish virtopsy as a cornerstone in modern forensic medicine. Firearm projectile tracing has a pivotal component of forensic ballistics, enabling the reconstruction of shooting incidents through the analysis of bullet trajectories, impact patterns, and ballistic signatures. This discipline integrates principles of physics, material science, and forensic pathology to determine the origin, direction, and behaviour of projectiles. Techniques such as trajectory reconstruction, striation pattern comparison, and gyroscopic motion analysis allow investigators to link bullets to specific firearms and firing positions. Virtual autopsy in case of gunshot injury in the foreseeable future, can become reliable alternative to traditional post-mortem techniques.***

Keywords: Virtual; Autopsy; Projectile; Tracing; Medicolegal autopsy

1. Introduction

The word "autopsy" has been derived from the Greek words "*auto*" and "*opsis*", that literally means "*an eye-witnessing, a seeing for oneself or to see with one's own eyes*". [1] A virtual autopsy, also known as a virtual post-mortem or digital autopsy or virtopsy, is a non-invasive technique of examining dead bodies to find out the cause of death. It does not destroy some important evidence which may be destroyed in the usual autopsy. It is a combination of CT and MR imaging, photogrammetry and 3D optical measuring technique, CT images give information about morbid anatomical findings and MR imaging demonstrates soft tissue injury, organ trauma, state of blood vessels, tissue and bones. [2] This innovative approach has revolutionized the field of forensic pathology, enabling investigators to conduct detailed examinations of deceased individuals without physically dissecting the body. [1]

Virtual autopsies typically employ computed tomography (CT), magnetic resonance imaging (MRI) or other imaging modalities to capture high-resolution images of the body's internal organs and tissues. These images can then be reconstructed into detailed 3D models, allowing us, the forensic experts to visualize injuries and pathologies, identify potential causes of death, and reconstruct crime scenes and events. It gives the benefits of minimally invasive or non-invasive procedures, preserving of the body for funeral or burial purposes, enhancing accuracy and detail in forensic analysis and drastically reducing the risk of contamination or evidence destruction.

Determining the cause and manner of the death is a critical aspect of post-mortem examination in cases of natural and unnatural deaths like homicide, suicide and accidents which comes for the autopsy. In firearm related crimes one of the main tasks of a forensic expert during autopsy is the projectile tracing and determining the projectile and extracting it from the body. This process of projectile tracing involves analysing the trajectory and characteristics of the projectiles to reconstruct the events of crime. By examining the entry and exit wounds of the bullet, with other internal evidences, a forensic expert can determine the type and calibre of the firearm used, reconstruct the trajectory of the projectile, identify the potential shooting angle and location and may also find out evidence of the specific firearm used.

2. Case Study

A 38 years old male got admitted to a private hospital with presenting complaints of gunshot injury over chest while riding as a pillion rider on a motorcycle while going home at evening. The vitals were unstable. The probable diagnosis made by the hospital was foreign body in the chest with pneumothorax and haemothorax with road traffic accident. He died within 2 hours of admission to the hospital. He was brought to the mortuary for medico-legal autopsy on same date.

External findings:

- Cold and moderately build body
- Rigor mortis: Well marked and generalised.
- Post-mortem lividity: Present over the back.

Mechanical Injuries:

- **Gunshot Injury:** An entry gunshot wound, placed obliquely, directed upwards to downwards from right to left, was present over the back on the left side, measuring 3.1 x 2.5 cm x thoracic cavity deep, situated 13 cm below the level of nape of neck on left side 13 cm away from the midline on the left side. The margins of the wound were contused with the lower edge of the wound bevelled due to the diagonal entry of the projectile. There was an inward thrusting of the soft tissues with tissue tags drawn inwards due to motion of the projectile. (Figure 1)
- **Head and Face:** Abraded contusion was present over the forehead and head on the right side, measuring 10 x 7 cm, situated 4 cm above the outer canthus right eye and over the temple on the left side, measuring 8 x 5 cm, situated 4 cm away from the left tragus, reddish in colour.
- **Left shoulder:** Abraded contusion was present over the top of the shoulder on the left side, measuring 9 x 7 cm, starting 1 cm inner to the left shoulder tip, reddish in colour.
- **Left forearm:** Abraded contusion was present over the outer aspect of arm on the left side, measuring 5 x 3 cm, situated 10 cm above the level of left elbow. Multiple abraded contusions were present over an area 12 x 8 cm, on the front and outer aspect of left forearm, varying in sizes from 1 x 1 cm to 0.5 x 0.5 cm, starting 5 cm below the left elbow. Reddish in colour.
- **Left knee:** Abraded contusion was present measuring 10 x 8 cm, in front of the left knee, reddish in colour.
- Multiple tiny abraded contusions were present over the front of chest and back of the body.
- All the above injuries were antemortem in nature; The abraded contusions mentioned were due to fall from bike.

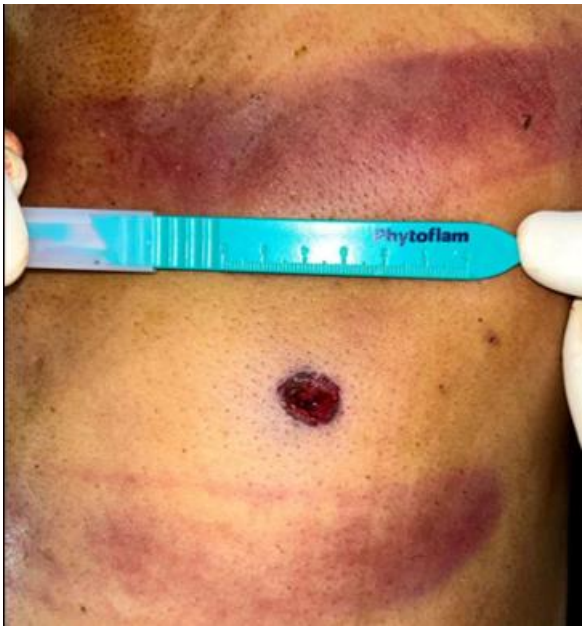

Figure 1: Gunshot entry injury

Imaging findings:

The dead body was shifted to imaging department for X-ray and CT imaging. X-ray of the chest (AP and Lateral) was taken to find out the projectile and the gross injuries internally caused by the projectile (Figure 2 & 3). A computed tomography (CT) scan using Hitachi 16 slice was performed to locate and track the projectile. This gave the exact location of the projectile (bullet). Furthermore, the scan provided detailed images of the internal organs and structures that got injured by the projectile (Figure 4).

Figure 2: Xray Thorax – AP view

Figure 3: Xray Thorax – Lateral view

Figure 4: CT Thorax showing the projectile (shining area) and collapse of lungs

Internal findings at Autopsy:

a) **Thorax:**

- There was defect in the intercoastal muscles corresponding to the gunshot injury between the 6th and 7th ribs on left side in midclavicular line and 2nd and 3rd ribs in thoracic cavity in posterior aspect. The bullet was recovered, which was lodged between the back of right 6th and 7th ribs along the midclavicular line. (Figure 7).
- Pleural cavity contained 2000 mL of fluid blood and 50 g of blood clots.
- Right lung: Penetrating injury to the outer aspect and inner aspect of the apical lobe.
- Left lung: Penetrating injury to the inner aspect and outer aspect of the lower lobe. (Figure 5)
- Pericardium and Heart: Perforating injury was present extending from left atrium to left ventricle.200 mL of fluid blood was present in the pericardial cavity. (Figure 6)

b) Abdomen:

- Stomach: 200 mL of brownish coloured fluid with partly digested unidentifiable food particles and no abnormal odour or smell.
- All organs were pale on cut section.

Figure 5: Showing penetrating injury of left lung due to gunshot

Figure 6: Showing perforating injury to heart due to gunshot

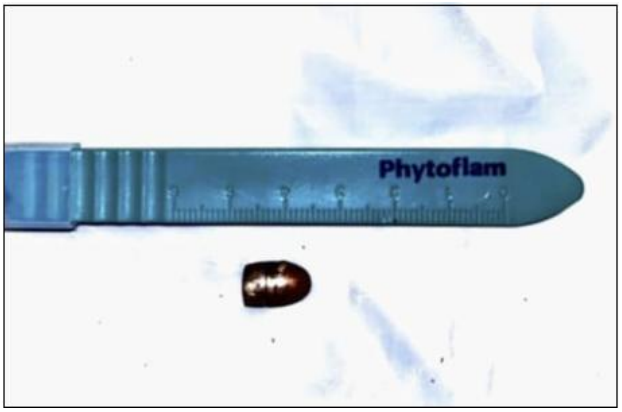

Figure 7: Showing the recovered bullet from the body

Tracing of the projectile:

Based on our imaging findings to detect the projectile and subsequent findings we got in the autopsy technique, the bullet trajectory is as follows:

Skin → Soft tissues → Muscles → Supraspinous fossa on the right scapula → Intercoastal space between the 2nd and 3rd right ribs from the posterior aspect of thoracic cavity → Outer aspect of the apical lobe of the right lung → Inner aspect of the apical lobe of right lung → Mediastinum → Left atrium of the heart → Left ventricle of the heart → Exited 1 cm above the apex of heart → Inner aspect of the lower lobe of left lung → Exited from the outer aspect of lower lobe of left lung → Projectile lodged in the intercoastal muscles between the 6th and 7th ribs in the midclavicular line in the anterior aspect of thoracic cavity. (Figure 8)

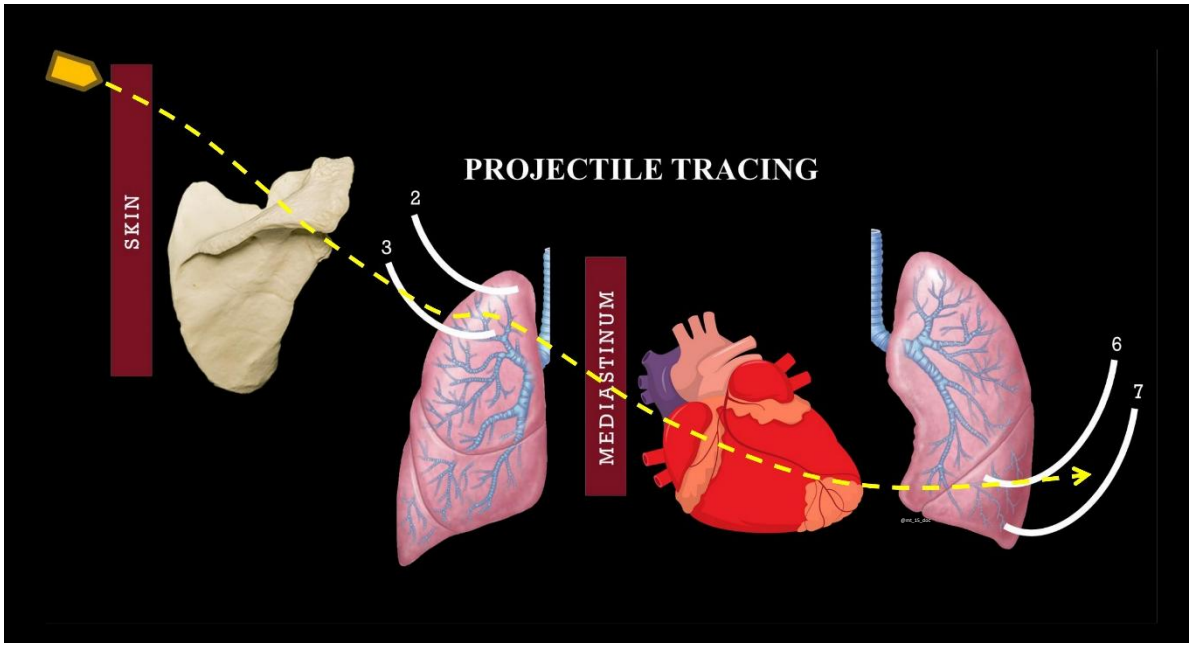

Figure 8: Showing the tracing of the projectile based on imaging and autopsy findings

3. Discussion

The conventional autopsy procedures comprise mutilating techniques that is sometimes sensitive in terms of emotional aspects of the victim's relatives, therefore majority of them object to performing autopsies**.** Use of imaging in medicolegal purposes was seen in forensic practice since 1896. [3]

Image-guided autopsy, also known as virtopsy, is a revolutionary and minimally invasive technique that enables the internal examination of deceased individuals using advanced medical imaging modalities, specifically computed tomography (CT) and magnetic resonance imaging (MRI). This innovative approach eliminates the need for traditional autopsy methods, which involve surgically opening the body

or removing organs. This virtopsy procedure typically involves: Scanning the body: The deceased is placed in a CT or MRI scanner, which generates detailed, high-resolution images of the internal structures; Image analysis: Radiologists and forensic experts analyse the images to identify any injuries, diseases, or other significant findings; 3D reconstruction: Advanced software is used to create 3D reconstructions of the internal organs and structures, providing a more comprehensive understanding of the body's internal layout and post-mortem biopsy.

In our study, the projectile was traced even before a traditional medicolegal autopsy. The CT scan conducted revealed the exact location of the bullet, hence helping to extract it out. It also helped us to find out the exact pathway the bullet entered and it travelled inside the body. In a study conducted by Cergan et al, [4] they reviewed the current status of virtual autopsy using combined imaging modalities. They also conclude as post-mortem computed tomography (PMCT) is highly effective for detecting complex osseous injuries, tracing bullet trajectories, identifying characteristic findings in drowning cases, examining intervertebral discs, and spotting Simon's bleeding. Post-mortem Computed Tomography Angiography (PMCTA) and Post-mortem Magnetic Resonance Imaging (PMMRI) also helps in identifying vascular lesions in natural death cases and lesions of brain and spinal cords. Post-mortem ultrasonography (PMUS) can also serve the purpose when PMCT and PMMRI are unavailable.

Study conducted by Anitha et al, [3] summarise about leveraging advanced imaging technologies, virtopsy revolutionizes the field of forensic medicine by providing comprehensive and detailed examinations of deceased individuals, contributing to more accurately determine the cause of death and facilitating collaborations among experts in different locations. [5] Study conducted by Rai et al, explore the various modalities of image guided virtual autopsy as an adjunct with radiographic and computed tomography modalities and the use of virtopsy as an important tool in forensic identification. Their main aspect of the study was to find out virtopsy using maxillofacial imaging as a technical tool in both research and forensic identification and reconstruction. They conclude that the virtopsy using maxillofacial imaging favours the development of future forensic investigations and is helpful in medicolegal cases.

In 2013, Makhlouf et al. [6] studied 47 gunshot victims with virtual autopsy and reported that CT scan is important in managing gunshot victims, helping in determining the firing distance in cases of contact range. A study done by Cirielli V et al, [7] to find out the virtual autopsy as a screening test before traditional autopsy. They conducted 25 virtopsies with the help of CT scans. The validity of virtual autopsy as a diagnostic tool is higher for traumatic deaths than other causes of death (accuracy 84%, sensitivity 82%, specificity 86%, positive predictive value 90% and negative predictive value 86%).

4. Conclusion

The benefits of virtopsy include minimally invasive by eliminating the need for surgical incisions, preserving the body's integrity. Detailed imaging using CT and MRI scans provide high-resolution images of internal structures, allowing for accurate diagnoses. Virtopsy minimizes the risk of contamination, making it an attractive option for cases where infection or biohazard concerns are present. Image-guided autopsy can also reduce the risk of human error associated with traditional autopsy methods which can provide a more dignified and respectful approach to autopsy, which can be comforting for families.

Ethical Clearance: A prior approval was obtained from the Institutional Ethical Committee.

Conflict of Interest: None to declare.

Source of Funding: None to declare.

Informed consent: None declared.

References

[1] Dr. Reddy Narayan K. S, Dr. Murthy O. P. The Essentials of Forensic Medicine and Toxicology, 34th ed. Jaypee Publications; 2017: p114-115.
[2] Joseph TI, Girish KL, Sathyan P, Kiran MS, Vidya S. Virtopsy: An integration of forensic science and imageology. J Forensic Ddent Sci.2017; 9: 111-4.
[3] Rai S, Misra D, Tyagi K, Prabhat M, Gangwal P. Image Guided Virtual Autopsy: An Important Tool in Forensic Identification. J Indian Acad oral Med Radiol.2017; 29: 368-70.
[4] Romica Cergan, Iulian Alexandru Taciuc, Mihai Dumitru, Daniela Vrinceanu, Felicia Manole, Nicoleta Sanda, Andreea Nicoleta Marinescu. The Current Status of Virtual Autopsy using Combined Imaging Modalities: A Scoping Review. J Cllin Med.2025;
[5] Anitha B, Deepa Lakshmi V, Dr Leo Carolyn. Virtopsy – Revolutionizing Forensic Pathology through Virtual Autopsies. Int J Contemporary Dent Research.2023; 4: 26-29.
[6] Makhlouf F, Scolan V, Ferretti G, Stahl C, Paysant F. Gunshot fatalities: Correlation between post-mortem multi-slice computed tomography and autopsy findings: A 30-months retrospective study. Leg Med (Tokyo) 2013; 15: 145-8.
[7] Cirielli V, Cima L, Bortolotti F, Narayanasamy M, Scarpelli MP, Danzi O, et al. Virtual autopsy as a screening test before traditional autopsy: The verona experience on 25 Cases. J Pathol Inform.2018; 9: 28.