CQ39: What postmortem imaging findings are useful for evaluating non-firearm penetrating trauma?

Recommendation Grade:

Assessment of condition: C1

Penetrating trauma frequently involves open skin wounds and is often accompanied by injuries to subcutaneous tissues or internal organs. On postmortem CT, when there is associated gas within tissues or bone injury, it may be possible to visualize the wound tract. In recent years, advances have been made in image reconstruction techniques that allow for visualization of the relationship between the injury and the causative instrument. However, postmortem CT alone has limitations in determining whether the injury occurred antemortem or postmortem, and in assessing whether the injury was fatal.

Explanation

● Background

Penetrating trauma refers to injuries in which the skin is penetrated by sharp or rod-like objects, often resulting in damage to subcutaneous tissues and internal organs. When the injury-causing instrument is a bladed object, the resulting injuries are classified as stab wounds or incised wounds; if both types are present, the injury may be referred to as a combined stab-incised wound. In contrast, injuries caused by small, blunt metallic objects traveling at high speed and high energy—i.e., gunshot wounds—are categorized separately as firearm injuries (see CQ40). Antemortem stab or stab-incised wounds typically gape open due to retraction of elastic fibers in the skin. Depending on the shape of the weapon, the wound may be spindle-shaped (as seen with round cross-sectional instruments) or have one blunt and one sharp end, such as with pointed single-edged blades like kitchen knives. Differentiation from blunt force injuries with skin lacerations, such as contused or split wounds, is essential.

● Postmortem CT Evaluation of Penetrating Trauma

In some cases, the wound can be visualized on postmortem imaging as a defect in the skin and subcutaneous tissue. Three-dimensional reconstruction using multislice CT (MSCT) allows for an overall understanding of wound morphology, and photorealistic rendering techniques such as global illumination have been reported to provide enhanced visualization[1]. However, wounds smaller than the slice thickness may not be detected, and color information is not available, making it generally difficult to assess for vital reactions such as bleeding within the wound tract[2]. In addition, bridging tissue—often seen in open wounds caused by blunt trauma[3]—is frequently undetectable due to resolution limitations, making it difficult to differentiate injury types based on imaging alone.

Gas or hemorrhage entering the wound tract, surrounding subcutaneous tissue, or damaged internal organs may sometimes be visualized depending on its amount and distribution[4]. In combined stab and incised wounds caused by sharp instruments (unlike gunshot wounds), the wound tract often collapses after the weapon is withdrawn. However, fatty infiltration along the weapon's trajectory can occasionally be identified[5]. Gas from a damaged hollow organ or external air entering through the wound may accumulate within vessels or heart chambers connected to the injury, helping to visualize the wound tract[5–7]. These findings can be useful for estimating the direction and approximate depth of the wound, as well as the affected organs. There have also been efforts to superimpose 3D CT images of the body surface, injured organs, and modeled weapons to visualize the relationship between the penetration pathway and internal damage[8].

It is often difficult to correlate postmortem CT findings with the characteristics of the weapon, due to factors such as changes in body position changes, inability to perform inspiratory breath-hold, time-related changes after the injury, and postmortem changes[5]. Nevertheless, fragmented blades have been reported within wound tracts or embedded in bone[59], which can help identify the weapon and improve safety for autopsy personnel.

Furthermore, postmortem CT angiography has been reported to allow identification of cardiac injuries or damaged vessels that were not evident externally[1011]. In cases of thoracic penetrating trauma involving lung injury, forced ventilation performed postmortem has reportedly helped in localizing the site of damage[12]. These adjunctive imaging techniques may enable a more detailed assessment of injury mechanisms. Postmortem CT is capable of visualizing bone injuries caused by the entry or exit of a weapon and hemorrhage within solid organs. However, as the position of organs may shift from their original anatomical location due to changes in posture or postmortem changes, care must be taken when estimating wound tract direction based on such findings[13]. Regarding differentiation between antemortem and postmortem injuries, as previously noted and discussed in other CQs, minor hemorrhage around the injured area may not be detectable on postmortem CT, and this limitation requires particular attention.

Column: Bridging tissue:
Tissue structures such as blood vessels, nerves, or connective tissue that remain intact and connect the opposing walls of a wound tract.

〇Search Strategy and Selection (as of December 4, 2023)

【PubMed】

#	Search formula	Number of articles
1	Search (postmortem CT） OR (postmortem computed tomography）	9,656

2	Search (postmortem MRI） OR (postmortem magnetic resonance imaging）	8,432
3	Search: ((stab） OR (sharp force)) OR (stabbing）	12,631
4	Search ((#1 OR #2) AND #3) Filters: English	44

●Additional Sources Not Captured by the Search Strategy

References［2］,［13］

■References

1) Fukumoto W et al：Global illumination rendering versus volume rendering for the forensic evaluation of stab wounds using computed tomography. Sci Rep 2022；12；2452（level 4b）
2) Villa C：Forensic 3D documentation of skin injuries. Int J Legal Med 2017；131：751-759（level 4b）
3) 検死ハンドブック 改訂 3 版（高津光洋），南山堂，2016
4) Langlois NEI et al：Arterial perfusion ー A useful technique for evaluating incised wounds. J Forensic Sci 2018；63：1282-1283（level 5）
5) Garetier M et al：Postmortem computed tomography findings in suicide victims. Diagn Interv Imaging 2017；98：101-112（level 5）
6) Borowska-Solonynko A et al：Significance of intracranial gas on post-mortem computed tomography in traumatic cases in the context of medico-legal opinions. Forensic Sci Med Pathol 2020；16：3-11（level 4b）
7）Gebhart FT et al：Gas at postmortem computed tomography—an evaluation of 73 non-putrefied trauma and non-trauma cases. Forensic Sci Int 2012；222：162-169（level 4b）
8）Takahashi Y et al：Superimposed CT imaging using fusion function to visualize the relationship between the knife and the wound path in a stabbing victim. J Forensic Sci 2021；66：1148-1153（level 5）
9）Kawasumi Y et al：Postmortem computed tomography images of a broken piece of a weapon in the skull. Jpn J Radiol 2012；30：167-170（level 5）
10) Ruder TD et al：Suicidal knife wound to the heart： challenges in reconstructing wound channels with post mortem CT and CT-angiography. Leg Med 2011；13：91-94（level 5）
11) Savall F et al：An unusual homicidal stab wound of the cervical spinal cord：a single case examined by post-mortem computed tomography angiography（PMCTA）. Forensic Sci Int 2015；254：e18-21（level 5）
12) Germerott T et al：Postmortem ventilation in cases of penetrating gunshot and stab wounds to the chest. Leg Med 2013；15：298-302（level 5）
13) Harcke HT et al：MDCT analysis of projectile injury in forensic investigation. AJR Am J Roentgenol 2008；190：W106-111（level 6）

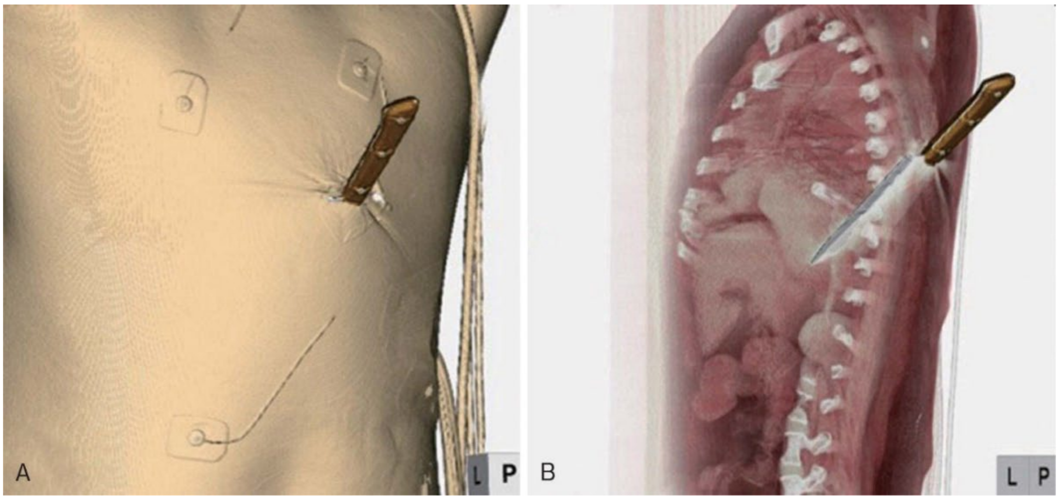

Figure 1. Male in His 50s (Antemortem Imaging on Hospital Admission)
The patient was stabbed in the right dorsal region with a knife. Volume-rendered (VR) CT imaging allows for clear visualization of the spatial relationship between the knife and surrounding organs. Even when CT is performed with the weapon still in place, interpretation is generally not impaired. (Courtesy of Dr. Keishi Ogura, Department of Radiology, Sapporo Medical University)

Figure 2. Male in His 70s with Multiple Stab-Incised Wounds
Both the conventional 3D reconstruction (A) and photorealistic rendering (B) enhance the visibility of the wound shape, allowing for easier identification of wound morphology and finer details such as wound angles.