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Case report

A moot point! A homicide case report on ambiguous projectile movement on postmortem MR

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ABSTRACT

In a case of homicide with a lodged ricochet projectile in the skull, potential projectile movement was investigated by postmortem magnetic resonance imaging (PMMR). The purpose of this case report is to evaluate the different PMMR-related properties of projectiles in gunshot wounds.

The deceased underwent whole-body postmortem computed tomography (PMCT) in a supine position, 3D-suface scanning with reposition of the corpse into a prone position and subsequent PMMR in the same position. For validation purposes, a control PMCT-scan in supine position followed by autopsy was also performed. The ferromagnetic properties of the projectile were tested.

Imaging revealed projectile movement between PMCT and PMMR. The bullet did not produce excessive susceptibility artifacts on PMMR. Autopsy revealed no heating effects of the adjacent tissue, indicating no thermal effects by the PMMR scan. The bullet showed no ferromagnetic properties. Ballistic analysis showed only copper and lead compounds in the 9 mm projectile. Therefore, the bullet migration was caused by repositioning of the corpse from a supine to a prone position along the ricochet wound channel, not by magnetic torque during the PMMR scan.

PMMR allows for better anatomical detail of the bullet path within soft tissue and may be performed in cases involving the vast majority of projectiles. Knowledge about potential ferromagnetic properties may have clinical implications for imaging in surviving patients of shootings. This case report shows that bullet migration may occur independently of magnetic torque and that the localization of the bullet during postmortem imaging and autopsy may have been altered in a ricochet shot.

1. Introduction

Postmortem imaging of gunshot wounds, either by two-dimensional x-ray or postmortem computed tomography (PMCT), to display lodged projectiles, trajectories and bullet paths is currently an established method in the field of forensic medicine [1–4].

Postmortem magnetic resonance imaging (PMMR), however, is seldom used to document bullets lodged within the body [5]. This is due to several factors, such as the poor availability of PMMR in morgues or affiliated hospitals, a lack of information about the behavior of projectiles, if lodged within the body in a magnetic resonance scanner, and simply time or economic issues. The magnetic properties of lodged projectiles within a corpse have been infrequently described in the literature, and prudence often occurs, particularly due to potential liability issues regarding the integrity of the PMMR suite [6–7]. Other known factors in ferromagnetic projectiles are possible susceptibility artifacts and heating of the surrounding tissue, which lead to a reluctance to perform PMMR in cases of penetrating and not perforating bullets [5,8–12].

1.1. Case history

In a case of multiple homicidal shootings, a bullet hit a 23-year-old male in the head. The perpetrator shot the victim from behind at a close range, resembling a typical execution-style murder. The body was found in the prone position with an entrance wound occipital to the head, and no exit wound was present.

2. Materials and methods

2.1. Postmortem computed tomography

PMCT scanning was performed on a 128-slice Dual Source scanner (Somatom Definition Flash, Siemens Medical Solutions,

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Forchheim, Germany). A whole-body scan was performed according to the institutional standard PMCT protocol. According to this protocol, the head and neck region was scanned separately with an adjusted field of view. The imaging parameters were a slice thickness of 0.6 mm and an increment of 0.4 mm in a hard or soft kernel and bone or cerebrum window, respectively. In addition, dedicated image reconstructions in thick slices (4 mm slice thickness, 3 mm increment) of the head were calculated [13]. Post-processing, including angulated multi-planar reconstructions, and three-dimensional (3D) reconstruction were performed on a Syngo.via workstation (Syngo software, Siemens Medical Solutions, Forchheim, Germany), and the Amira software was used for segmentation (Amira-3D Analysis Software for Life Sciences, Visualization Sciences Group, an FEI Company, Houston, TX, USA)

2.2. Surface documentation

In combination with a separate whole body PMCT scan, a detailed 3-dimensional surface scan and photogrammetry were performed using the Virtobot system [14–16]. A detailed workflow on the surface scanning has been described in the literature by Ebert et al., Naether et al. and Breitbeck et al. [14–17].

2.3. Postmortem magnetic resonance imaging

PMMR imaging was performed using a 3-Tesla magnetic resonance scanner (Achieva 3.0 TX, Philips Medical System, Best, The Netherlands) using an 8-channel SENSE-head-coil with a coil diameter of 24 cm and a coverage of 22 cm. The PMMR head protocol includes spin-echo sequences (T2-weighted TSE, T1-weighted IR TSE) with a slice thickness (SL) of 4 mm, sagittal 3D acquisitions (T2-weighted TSE, FLAIR, SL 0.55 mm) and a hemo-sequence (venous BOLD, SL 0.5 mm). The analysis also included diffusion-weighted images (DWI) and diffusion tensor images (DTI). The total PMMR scan time was 40 min.

2.4. Imaging workflow

The initial PMCT scan was performed with the corpse in the supine position. After PMCT, the body was prepared for a 3D surface scan of the occipital entrance wound of the head, for which the corpse was turned into a prone position. The CT-scanner was occupied by another surface scan (including PMCT), so the time interval was used to perform PMMR of the head. Therefore, the body remained in the prepared prone position for the later surface scan. The time interval between the initial PMCT and the PMMR scan was 5 h, based on the time required to prepare for the 3D scan and the availability of the MR scanner. PMMR revealed a dislocation of the projectile that was not further altered during the entire PMMR. A surface scan was later conducted in the prepared prone position. The body was stored prone in the cooling cell over the rest of the night, and an additional control PMCT was performed in the supine position the next morning (the corpse was turned and left supine for 15 min prior to PMCT) immediately before the autopsy (Fig. 1).

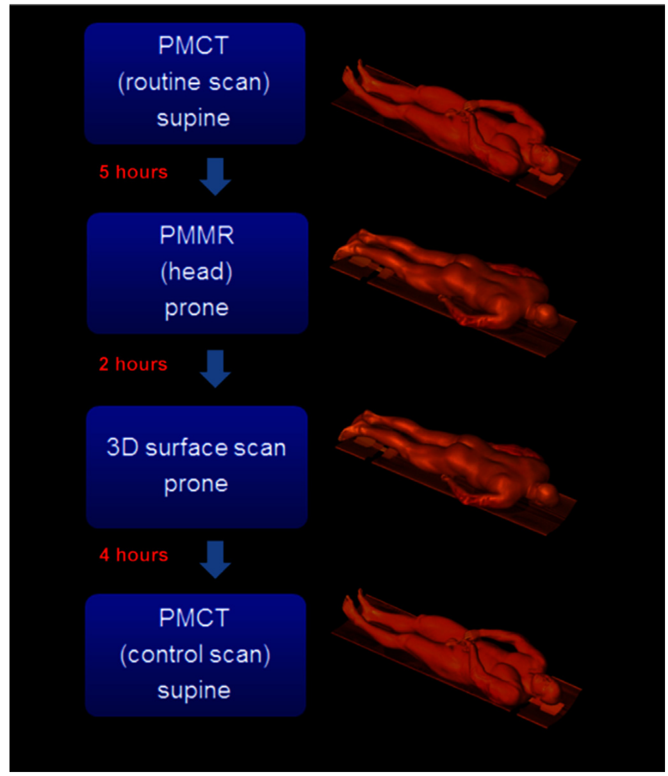

Fig. 1. The comprehensive imaging workflow, the time interval and the corpse's position during virtual autopsy are displayed.

3. Results

3.1. Radiological findings

Initial PMCT (supine position) revealed a slight right paramedian occipital entry wound with typical inwards beveling of the calvarium and dispersed bony fragments along the intracranial wound channel, indicating the entry wound. The median ascending posterior–anterior bullet path indicated a ricochet, bouncing at the frontal internal table with a subsequent, slightly dislocated crater-like large fragment of the frontal skull. The penetrating shot led to a lodged projectile at the left interhemispheric parietal (cranial to the side ventricles) position (Fig. 2). PMCT presented extensive streak artifacts due to the metallic properties of the bullet. The ricochet projectile showed bullet migration along the wound channel on PMMR (prone position) from an interhemispheric position to a frontal, slightly left-sided (superior frontal gyrus) location of the bullet. PMMR, however, did not exhibit any susceptibility artifacts but instead showed a "black hole", leading to the assumption that the bullet did not contain any ferromagnetic properties. The 3D surface scan combined with PMCT (prone, directly after PMMR) and a control scan (supine, the following morning) confirmed the PMMR findings of a more frontal location of the bullet (Fig. 3).

3.2. Autopsy

The manner of death was determined a homicide, and the cause of death was stated as central regulatory failure. Autopsy confirmed the radiological findings, and the bullet was retrieved as evidence during dissection. The distorted projectile was allocated at the frontal location (left superior frontal gyrus), as observed on PMMR and the control PMCT. The adjacent soft tissue showed no thermal heating effects (Fig. 4).

3.3. Ballistic investigation

The secured bullet was also tested for ferromagnetic properties simply by using a standard magnet (Webcraft GmbH, Uster, Switzerland), and no magnetic attraction could be detected. For proper testing, the projectile was then taken into the anterior center of the tube of the previously used 3-Tesla scanner without any magnetic torque on the bullet.

Ballistic compound analysis showed only copper and lead compounds in the 9 × 17 mm projectile (.380 ACP (Automatic Colt