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Case Report

Usefulness and limitations of postmortem computed tomography in forensic analysis of gunshot injuries: Three case reports

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ABSTRACT

Gunshot injury has always been an important field of investigation in postmortem forensic radiology. The localization and retrieval of the bullet and of potentially important fragments are vital to these cases. Using postmortem multidetector-row computed tomography (MDCT) prior to forensic autopsy, we sought to illustrate the importance of this modality in the noninvasive characterization of gunshot wounds. We obtained and analyzed MDCT images in three cases of gunshot wounds (accidental close-range shotgun shooting, suicidal contact gunshot to the head and accidental long-range buckshot shooting). We discuss the value of postmortem MDCT findings in gunshot wound cases by comparing with forensic autopsy findings in Japan, a developing country with miserably low autopsy rate.

1. Introduction

Forensic radiology methods in the routine practice of forensic pathology are widely recognized [1,2]. Particularly for gunshot cases, multidetector-row computed tomography (MDCT) scanning provides realistic images of indriven bone and projectile fragments and allows estimation of the projectile trajectory, as well as indicating brain injury, including mass effect and intracranial hematomas [3]. It is important to locate the projectile's entry, path through the body, and, if present, exit location. Forensic investigations of death by suspected projectile injuries require the examiner to differentiate between homicidal, suicidal, and accidental shootings. For example, the course of a bullet through the body can give clues about the positional relationship of the victim and the assailant and how the victim was shot [4]. MDCT can provide detailed information about gunshot wounds prior to forensic autopsy.

From May 2009 to December 2014, we performed plain radiography and computed tomography (CT) before forensic autopsy in 1096 suspicious death cases. During this period, we have experienced mere three gunshot death cases. We discuss the benefits and limitations of postmortem CT images in the cases of gunshot wounds, comparing with forensic autopsy findings in this report.

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2. Methods

2.1. Postmortem radiography

As part of pre-autopsy screening, postmortem plain radiography was performed with a mobile plain X-ray system (MobileDaRt®; Shimadzu Corporation, Kyoto, Japan), integrated with a digital flat-panel detector (CXDI-50G®; Canon Medical Equipment Group, Tokyo, Japan). Postmortem CT scanning was performed with an 8-slice scanner (Aquilion®; Toshiba Medical Systems, Tokyo, Japan), using a thin slice thickness of 1.0–2.0 mm and a beam pitch of 0.875. Images were reconstructed with soft tissue, lung, brain and bone kernels. There is a tradeoff between noise and resolution, so noise can also be reduced by increasing the slice thickness. With increased noise, high contrast objects such as bone may still be visible, but low contrast soft tissue boundaries may be obscured. Thus, CT images require generation of separate images utilizing different reconstruction kernels to optimize lesion detection. Maximum intensity projection (MIP) images are achieved by displaying only the highest attenuation value from the data encountered by a ray cast through an object to the viewer's eye [5,6]. The MIP is best used when the objects of interest are the brightest object (high X-ray attenuated material) in image. However, most MIP methods use only windowing parameters (window width and center, specified in CT-number) and not color. MIP display is a two-dimensional representation that cannot accurately depict the actual three-dimensional (3D) relationships [7].

The images were viewed as axial slices, multiplanar reconstructions (MPR), MIP and 3D reconstructions by a 3D image workstation server (ziostation ver. 2.1.5.0; Ziosoft, Tokyo, Japan) by two board-certified radiologists who had more than 10 and 25 years of experience, respectively, in tomographic imaging and more than 5 years of experience in interpreting postmortem CT. The use of postmortem CT images for this research was approved by the ethics board of our institute. Informed consent was not required for this research.

3. Results and discussion

3.1. Case 1

A man in his 70s who went bird hunting in the forest was found dead in a supine position. A wound was found on the right side of the chest (Fig. 1a). A little soot staining from burned gunpowder was deposited on his cloth jacket (as shown in the insert of Fig. 1a). According to the police investigation, he seemed to be using the over/under double barrel (12-gauge) shotgun loaded with birdshots as a walking stick when climbing a muddy slope, and slipped and tumbled down the steep hillside.

Postmortem CT scanning was performed 18 h after finding the body. A postmortem thoraco-abdominal CT showed a large soft-tissue defect on the skin surface of the right anterior chest that appeared to be the entrance wound (Fig. 1b). It also highlighted multiple rib fractures (Fig. 1c), the presence of approximately 200 shotgun pellets in the body (Fig. 1d), and an associated right lung injury. These 3D images were reconstructed from 2.0-mm slice thickness images with 50% overlap (in every 1.0-mm) using soft tissue kernel for the reduction of metal artifact from a lot of pellets. The information on the position of metal fragments left in the body gave valuable information about the proximity of the firearm, and has the potential to provide information on the position of fragments to prevent injury to autopsy personnel. Also visible was a large amount of bleeding in the right pleural cavity, displacement of the mediastinum to the left side, and an empty right atrium and ventricle. A small amount of gas was in left ventricle and ascending aorta. There was no exit wound to the back and most of the shotgun pellets remained in the soft tissues; four pellets were found in the liver. Other possible causes of death including intracranial hemorrhage and abdominal injury were not observed. Intracranial gas babbles was not also found.

At autopsy, the body measured 149 cm in height and weighed 57 kg. There was no intracranial hemorrhage or abdominal injury. There was a little livor mortis, reddish coloration on a part of the cervical and lumber back surfaces. An ellipsoidal wound with a cutaneous defect, measuring 8×10 cm, was visible in the right anterior chest. The edge of the wound was reddish and abraded. This finding, however, is not evident on every MDCT images other than direct viewing the external surface of dead body. Powder tattooing which is caused by the impact of intact or partially burned gunpowder particles from firing a muzzle at non-contact range on the skin [8,9], and satellite pellet holes caused by the fanning out of pellets on their trajectory towards the skin [8,9] were not confirmed. The right lung weighed 340 g and was severely damaged (Fig. 1e). There was 350 g of hematoma in right pleural cavity. The right atrium and descending aorta were hit by pellets. The liver weighed 980 g and was not congested; a few pellets were identified in the parenchyma (Fig. 1f). The shot cup for minimizing the deformation of shot over distance [8,9] was found in the right pleural cavity after removal of the right lung (Fig. 1g). However, the shot cup in the pleural cavity was not visible on postmortem CT. It was confirmed that some pellets had penetrated the soft tissues of the right side of the back, but none had punctured the skin. The residual blood volume in the heart was slightly 50 mL. The frothy appearance of the blood was not seen.

Of course, cardiac pump failure due to gas embolism occurred secondary to trauma and cardiac arrest due to tension pneumothorax was considered as the possible cause of death on CT findings alone. However, there was not intracranial gas babbles on CT and frothy appearance of the blood at autopsy. We recognized that there were limitations in postmortem MDCT imaging could not match the external examination and forensic autopsy findings. Considering the characteristics of the entrance wound and the location of the shot cup in the right pleural cavity, we concluded that they were produced by a contact-range shotgun discharge. There was not any toxic substance in the urine and blood samples. The victim died from massive thoracic injuries.

3.2. Case 2

A man in his 50s was found dead in a sitting position in the seat of his car. The police found an auto-loading pistol (Tokarev TT-33 type) clasped in his right hand, with his second finger on the trigger, and gunshot injuries were found in both temporal regions. The scene investigation provided strong evidence that the manner of death was suicide using a pistol.

Postmortem CT scanning was performed 25 h after the body was found. CT imaging of the head displayed extensive fractures underlying the two scalp lacerations. MIP coronal images indicated a severe depressed fracture together with some of its fragments in the right temporal area (Fig. 2a) and radiating fractures on the left temporal side (Fig. 2b), confirming the entrance and exit wounds to be on the right and left sides, respectively. The substantially circular bone defect part at entrance wound was approximately 8 mm in diameter. These MDCT findings of fractures are very important for determining the projectile direction, resulting severe damage to brain along the bullet path. There was no bullet lodged in the cranial cavity. Three major fracture lines extended to the left parietal bone, as shown in Fig. 2c. MDCT also showed the bullet track through the brain, with a hematoma and bone fragments seen along the trajectory path (Fig. 2d). The CT images of skull fractures reconstructed from 1.0-mm slice thickness images using bone kernel to indicate detailed bone fractures. Fig. 2d was 3.0-mm slab thickness MPR image reconstructed from 1.0-mm slice images using the brain kernel to reduce noise and beam hardening artifact. On the dorsal side of both lungs, there was congestion due to hypostasis. No thoracic or abdominal injury was visible with CT and no upper or lower-extremity fractures were confirmed.

At autopsy, the body was 162 cm in height and weighed 61 kg. Deep lacerations of the scalp forming a star shape, without gunpowder residue or soot on the wound edge, were found in the right posterior temporal area. This suggested that the gun was held in tight contact. On the opposite side, a much smaller laceration was also found in the left temporal area. Skull fractures corresponding to those on postmortem CT 3D imaging, as well as a subarachnoid hemorrhage encompassing the entire brain, were found. Severe damage of the brain tissue along the trajectory path was confirmed in the near-axial cut surface of formalin-fixed brain at a later date (Fig. 2e). The residual volume of blood in the heart was 110 mL. The right and left lungs weighed 480 and 400 g, respectively. There was severe pulmonary congestion at the lower lobe of both lungs. We confirmed that the thoracic and abdominal organs showed no fatal damage or significant pathological alteration. Toxicological analysis of the urine using gas chromatography mass spectrometry showed methamphetamine. The decedent died of the massive traumatic injury to the central nervous system.