CQ36 What are useful findings on postmortem images to assess penetrating trauma (gunshot wounds)?

Grades of recommendations:
B for evaluating the condition
C2 for determining the cause of death

Postmortem CT are useful here because they enable evaluation of gunshot wounds from various findings. In particular, it is useful for locating the bullet itself, counting the number of bullets in the body, identifying fatal injuries, pointing out bullet fragments, fractures, air embolisms, pneumothorax, and pneumocephalus. However, postmortem CT may not be sufficient for evaluation of organ injuries. Therefore, it is not recommended to determine gunshot wounds as the cause of death from postmortem CT alone.

Explanation----------
Background

A gunshot wound is an injury caused by a bullet or gunpowder fired from a firearm. Depending on whether or not the bullet has perforated the victim, bullet wounds are divided into perforating gunshot and penetrating (non-perforating) gunshot wounds. As a special gunshot wound, there is a ricochet gunshot wound where the bullet bounces off bone and goes through and out of the body again. In an autopsy, it is necessary to collect the bullets if the wound is a penetrating gunshot wound. For perforating gunshot wounds, it is necessary to determine the entrance and exit, to evaluate the direction of the bullets, and to estimate the type of firearm. It is also important to estimate the range the bullet has been fired from (whether it is close-range, intermediate-range, or distant), mainly from findings on the skin. To evaluate the cause of death, it is important to evaluate whether there are fatal injuries by the gunshot wound and whether it is an antemortem gunshot wound with a vital reaction.

Postmortem CT evaluation

Gunshot wounds have long been known in forensic medicine as a field in which diagnostic images are useful. From the early 2000s till recent years, when postmortem CT began to be applied in forensic medicine, there are papers supporting the usefulness of postmortem CT for this determination [1-9]. Most of the papers are retrospective studies comparing with an autopsy as superior method for standard results. The details considered in these papers were as follows: the bullet itself [5], the number of bullets in the body [8], bullet fragmentation [1-3, 5], caliber evaluation [8], entrance/exit identification [1-8], wound evaluation [1, 3-8], estimation of the range of the firing [7], identification of fatal injuries [3, 4], evaluation of the cause of death [5], presence or absence of blood aspiration as a complication

of head and neck gunshot wounds [2, 9], evaluation of fractures [1, 2], air embolisms [2, 7], pneumothorax [7], pneumocephalus [1], midline shift [7], hemorrhages [1-4], and organ injury evaluations [1-4, 7]. Postmortem CT has reported that each of these indicators can be evaluated to some extent. In particular, the bullet itself [3, 8], the counting of the number of bullets in the body [8], and the identification of fatal injuries [3, 4], autopsy and postmortem CT almost all reach equivalent conclusions. To evaluate the following particulars, postmortem CT are considered more effective than autopsies [1, 7]: bullet fragments [3, 8], some fractures (face fracture, cervical spine or pelvis injuries) [3, 7], air embolisms (gas in the heart and large blood vessels), pneumothorax, and pneumocephalus. Based on these reports, postmortem CT prior to an autopsy are recommended in gunshot wound cases. Postmortem CT are considered to be insufficient because postmortem CT do not accurately match an autopsy with a following evaluation of gunshot wounds: the wound track [3], the caliber of bullets [8], the shooting range [7], the cause of death [5], organ injuries [3, 7], and skull base fractures [7]. There are also reports of cases where the radiologist has made mistakes in the evaluation of the gunshot wound (it was evaluated as a penetrating gunshot wound by postmortem CT, but was actually a ricochet gunshot wound) [10]. In the only systematic review conducted in recent years, postmortem CT are not a full replacement for an autopsy and is recommended for use as an adjunct to an autopsy [11].

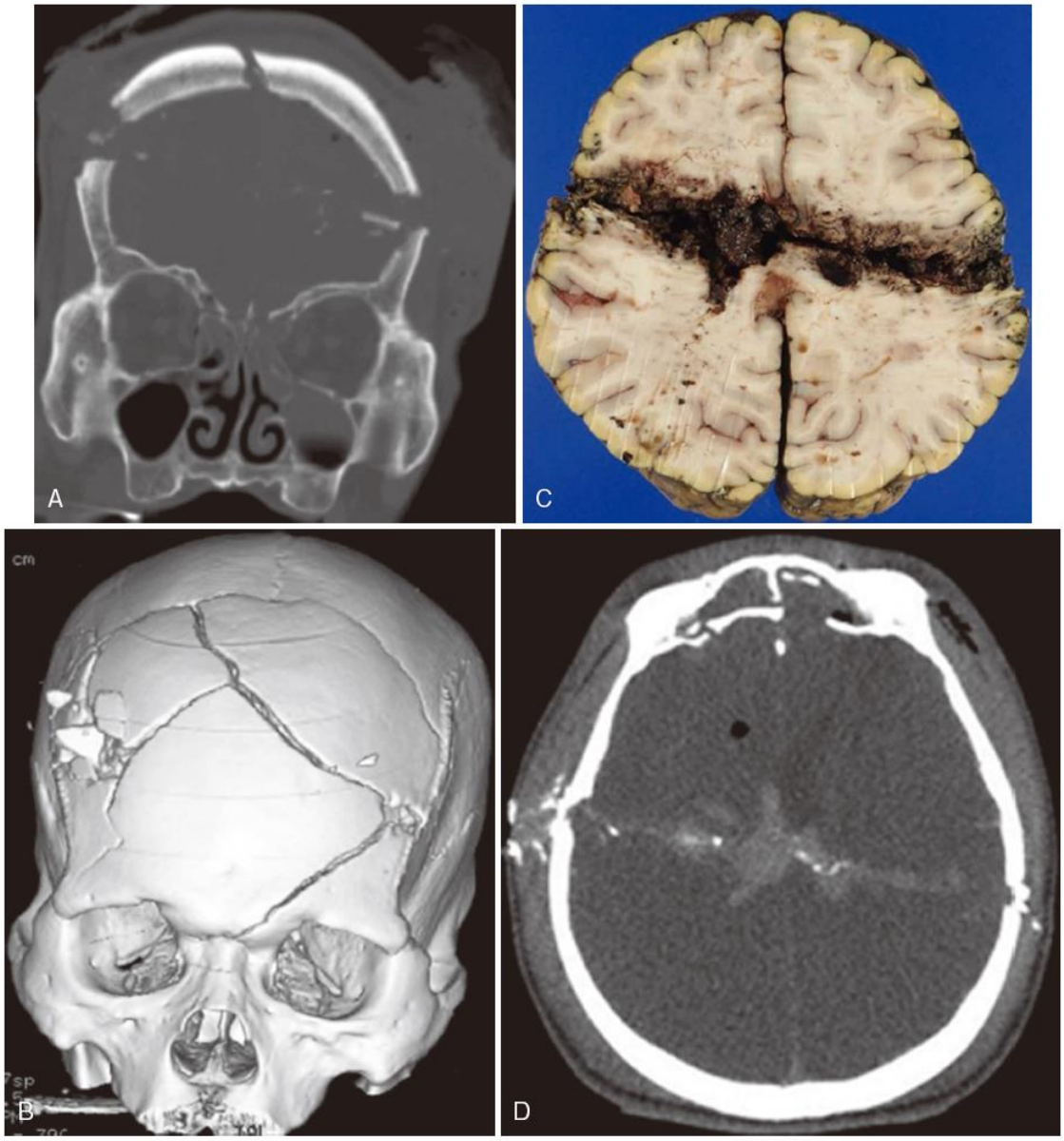
Who should interprete the postmortem images

Regarding interpretation, there is one paper comparing the following items in two groups, a group of two radiologists and a group of one radiologist and one forensic scientist; evaluation of the number of bullets, evaluation of the wound cave, direction of the gunshot wound (identification of the entrance and exit), evaluation of the caliber and debris of the bullet. It was concluded that there was no difference in interpretation between the two [8]. In addition, multiple documents suggest that image interpreter with a large number of experiences have fewer mistakes, suggesting that experience is important for the interpretation of gunshot wounds [4, 8, 11].

About modality other than postmortem CT

The literature comparing plain X-ray examinations and postmortem CT examinations concludes that three-dimensional evaluation with postmortem CT is useful for more accurate evaluation of gunshot wounds [4]. Postmortem MRI has been investigated in some literature and has been shown to have the potential to complement the weaknesses of postmortem CT such as organ damage [1, 2]. If the bullet is ferromagnetic, it may move within the wound cavity during image acquisition time [12] and is not recommended due to forensic problems.

Figure Gunshot wound



A CT coronal, B VR image, C autopsy macroscopic image (reverse right to left), and D CT image at the same height as image C

The postmortem CT shows gunshot wounds in the left and right temporal regions and fractures in the frontal region. As the bullet is not in the skull, it is a perforating gunshot wound (A). The VR image clearly shows the distribution of bone fragments and the course of the fracture line formed by the gunshot wound. The left-side wound is the entrance and the right-side is the exit (B). There is a wound in the brain parenchyma (C). With the postmortem CT it is easier to identify bone fragments (calcifications) than with the autopsy. (Courtesy of Dr. Hideyuki Hayakawa. Tsukuba Autopsy Center)

Literature search formula and literature selection (2019/ 6 /2)

PubMed

#	Search formula	Number of documents
1	((((((((((postmortem)OR post-mortem)OR “post mortem”))AND imaging))OR(((((postmortem)OR post-mortem)OR “post mortem”)) AND CT))OR(((((postmortem)OR post-mortem)OR “post mortem”)) AND “computed tomography”))OR(((((postmortem)OR post-mortem) OR “post mortem”))AND MR))OR(((((postmortem)OR post-mortem) OR “post mortem”))AND “magnetic resonance”)))OR(((((postmortem) OR post-mortem)OR “post mortem”))AND MDCT))OR((MSCT) AND(((postmortem)OR post-mortem)OR “post mortem”))	23,659
2	“gunshot”	17,671
3	#1 and #2	156

Ichushi（Medical Journal）

#	Search formula	Number of documents
1	(死後/AL)and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	4,582
2	(死亡時/AL)and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	683
3	((画像診断/TH or 画像診断/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	270,065
4	((X 線 CT/TH or X 線 CT/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	103,856
5	((MRI/TH or MRI/AL))and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	86,742
6	#1 or #2	5,058
7	#3 or #4 or #5	280,349
8	#6 and #7	1,228
9	((銃創/TH or 銃創/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	156
10	#8 and #9	15

References

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[2] Thali MJ et al: Image-guided virtual autopsy findings of gunshot victims performed with multi-slice computed tomography and magnetic resonance imaging and subsequent correlation between

radiology and autopsy findings. Forensic Sci Int 2003; 138: 8-16 (Level 5)

[3] Levy AD et al: Virtual autopsy: preliminary experience in high-velocity gunshot wound victims. Radiology 2006; 240: 522–528 (Level 4b)

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[9] Scaparra E et al: Detection of blood aspiration in deadly head gunshots comparing postmortem computed tomography (PMCT) and autopsy. Eur J Med Res 2016; 21: 43 (Level 4)

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[12] Luijten M et al: Can postmortem MRI be used to assess trajectories in gunshot victims? Int J Legal Med 2016; 130: 457-462 (Level 6)