CQ43 What are useful findings in postmortem images to determine burn deaths (fire-related deaths)?

Grades of recommendations:
C1 for evaluating the condition
D for determining the cause of death

In determining burn death, it is necessary to evaluate vital reactions such as soot in the respiratory tract and/or blood carbon monoxide hemoglobin saturation. Since these cannot be evaluated on postmortem images, postmortem images cannot determine burn death. However, postmortem CT are useful as they may be useful to provide findings that are difficult to detect with an autopsy (for example, trauma such as bone fracture, foreign objects such as bullets, and findings related to individual identification, and others). Postmortem CT observations are recommended for corpses found at fire sites as an aid to autopsies.

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

Burn death is a general term for deaths related to fire. Burn death is thought to be a combination of burn shock, respiratory tract burn, carbon monoxide poisoning, cyanide poisoning, and oxygen deficiencies associated with fires. Among skin burns, I-II degree burns such as erythema and blistering generally indicate that the deceased suffered burns ante-mortem (vital reaction). However, the outer surface of a deceased body found at a fire site is often highly charred.
It is necessary to confirm the vital reaction for a finding to be accepted as an ante-mortem burn.
For that purpose, it is necessary to determine by an autopsy that the soot is inhaled into the respiratory tract and/or that the blood carbon monoxide hemoglobin saturation level is increased.

Evaluation of burn death by postmortem images

In postmortem images, it has been reported that vital reactions at burn death include tongue protrusion [1], pulmonary edema [1], and gas embolism [2] on postmortem CT. However, these are neither well-defined scientific findings nor forensically accepted. In a study of 50 postmortem CT of fire-related deaths, it has been reported that it is difficult to evaluate the soot and/or blood carbon monoxide hemoglobin saturation increase, which is a vital reaction to burn death [3].
In total, there are no useful findings for determining burn death (fire-related death) based on postmortem images.

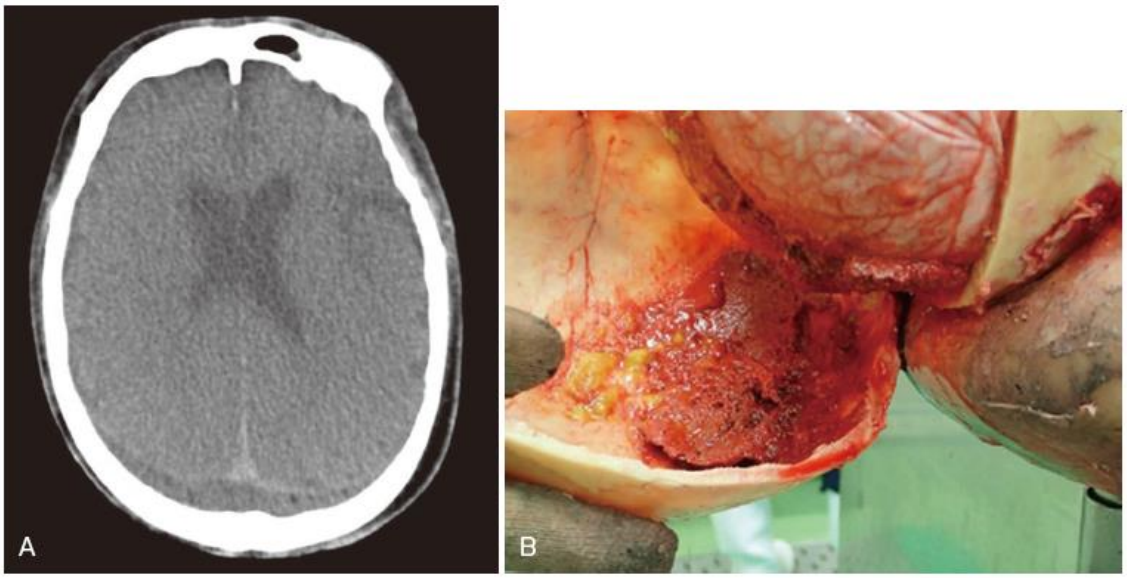
Lung findings related to burn death (fire-related death)

An examination of death cases caused by fire burns reported that a comparison between a burn death group (n=6), a carbon monoxide poisoning death group (n=7), and a sudden cardiac death group (n=10) showed the ratio of low CT values (-2,000 to -400 HU) in the lungs, or that the effective lung aeration ratio was significantly higher in the burn death group [4]. In addition, it was reported that lung attenuation was reduced in the burn death group when the effect of carbon monoxide poisoning was low [4]. A decrease in lung attenuation alone can be seen in other causes of death and cannot be used to make a determination of burn death, it is however considered as a reference finding.

Usefulness of postmortem images in fire-related deaths (other than cause of death)

Postmortem images cannot determine the cause of death in fire-related deaths, but it is useful as an aid to an autopsy because it can evaluate trauma elements (especially fractures) and foreign substances/ objects such as gas and bullets that are difficult to identify by autopsy [3, 5]. Postmortem CT has been useful in personal identifications (disaster victim investigations) in a large number of deaths occurring with wildfires (human/non-human differentiation, sex determination, age estimation, discovery of medical devices, and others) [6]. In addition, it has been reported that postmortem CT in burn deaths are useful as a guide for sample collection [1]. Both postmortem CT and postmortem MRI have been concluded to provide a similar utility and usefulness [2, 7, 8].

Figure Male in the 60s, heat hematoma (2 days after death)



A CT: A structure is seen in the posterior part between the skull and brain extending in a crescent shape beyond the midline, shows a slight low attenuation from the brain parenchyma, and a lower density inside the structure. Contraction of the brain parenchyma and dura mater is notable.

B Autopsy macroscopic findings: The skull is opened, and the inside is observed from the right rear direction. There is a red hematoma-like structure attached to the occipital bone. It represents a so-called heat hematoma. A heat hematoma is a solidified mass of blood (and other components) that has leaked into the space created in the epidural space due to the contraction of the dura under the influence of heat (after death).

A heat hematoma on postmortem CT has the characteristic of spreading beyond the midline. The shape resembles a subdural hematoma. Its presence in the epidural space and localized low attenuations of the inside is distinguishing features. Further specification of details is necessary based on the situation where the deceased was found.

Column----------

Postmortem CT on charred cadavers (corpses with severe burns to the whole body found at a fire site, whether ante-mortem burned or not) are not always useful in evaluating burn death but various characteristic image findings can be observed.

Burning or heat hematomas may be the most well-known finding on charred cadavers. It is formed by high heat that causes the brain and dura to heat condense within the cranial cavity, allowing blood to seep into the epidural space from the skull. Postmortem CT findings include fluid retention in the epidural space, but unlike acute epidural hematomas, they are crescent-shaped similar to subdural hematoms and have relatively low attenuation [1-3, 5]. In addition, if the heat condensation of the dura is stronger than that of the brain, the dura may break and the brain may escape into the epidural region. Such dural tearing or epidural cerebral hernias may also be observed on postmortem CT [1, 3].

The skull may show a characteristic fracture due to heat on the outer plate, with the disappearance of skin and subcutaneous tissue. At times, only the outer plate disappears over a wide area. Postmortem CT also show a characteristic skull fracture in which only the outer plate was peeled off and the inner plate was retained, this is termed a split diploë sign [1, 3, 5].

In charred cadavers, the chest and abdominal walls are extensively destroyed, and ruptured, and sometimes the small intestine is escaped from the ruptured abdominal wall. Postmortem CT show findings corresponding to pneumothorax and gas in the abdominal cavity, and in organs such as the lungs and liver, attenuation changes may be observed only on the surface due to surface thermal changes. This is termed a dense border sign [3].

In the extremities, the heat condensation of the flexor muscles is stronger than that of the extensors, resulting in a peculiar position like a fighting pose known as the martial arts position. The resulting flexion of the joint is also observable on postmortem CT. The patella may be dislocated and moved proximally by a similar mechanism [3]. If thermal denaturation progresses further in the extremities, transection of the extremities, the so-called thermal amputation, occurs [1, 3, 5]. The fractured part has no soft tissue, the stump is relatively smooth, and sometimes shows a hemispherical fractured surface like the part where the mouth part of a whistle is applied (flute mouthpiece) [1]. When looking at the bone marrow of a fractured part, gas may be mixed in the spots, resulting in low attenuation,

which is called mottled lucency [3, 5].

Again, it should be noted that these findings are only postmortem changes due to heat and do not contribute to a determination of burn death.

Literature search formula and literature selection (2019/2/18)

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	“burned death”	4,259
3	#1 and #2	35

Ichusi（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	((焼死/TH or 焼死/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	58
10	#8 and #9	4

From other than search formula

[8]

References

[1] Coty JB et al: Burned bodies: post-mortem computed tomography, an essential tool for modern forensic medicine. Insights Imaging 2018; 9: 731-743 (Level 6)

[2] Thali MJ et al: Charred body: virtual autopsy with multi-slice computed tomography and magnetic resonance imaging. J Forensic Sci 2002; 47: 1326-1331 (Level 5)

[3] de Bakker HM et al: The value of post-mortem computed tomography of burned victims in a forensic setting. Eur Radiol 2019; 29: 1912-1921 (Level 4)

[4] Sogawa N et al: Postmortem volumetric CT data analysis of pulmonary air/gas content with regard to the cause of death for investigating terminal respiratory function in forensic autopsy. Forensic Sci Int 2014; 241: 112-117 (Level 4)

[5] Levy AD et al: Multidetector computed tomography findings in deaths with severe burns. Am J Forensic Med Pathol 2009; 30: 137-141 (Level 4)

[6] O'Donnell C et al: Contribution of postmortem multidetector CT scanning to identification of the deceased in a mass disaster: experience gained from the 2009 Victorian bushfires. Forensic Sci Int 2011; 205: 15-28 (Level 4)

[7] Sano R et al: Use of postmortem computed tomography to reveal intraoral gunshot injuries in a charred body. Leg Med 2011; 13: 286-288 (Level 5)

[8] Iwase H et al: Evidence for an antemortem injury of a burned head dissected from a burned body. Forensic Sci Int 1998; 94: 9-14 (Level 5)