CQ44 What are some useful postmortem imaging findings that can help identify hypothermia?

Grades of recommendations:
C1 for evaluating the condition
C2 for determining the cause of death

If postmortem CT show a well-aerated lung, a postmortem clot (mold-like cylindrical high attenuation body) in the heart and large blood vessels, and a large amount of urine in the bladder, this may indicate hypothermia.

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

Hypothermia is a lethal condition in which body temperature declines along with life support functions owing to cold, and it can cause death. Autopsy findings of hypothermia are as follows: gastric mucosal hemorrhagic spots (Wischnewski spots), differences in the color of the left and right heart blood, soft blood clots and chicken fat clots in the heart and large blood vessels, lungs without edema, and a large amount of urine retention.

Although these findings suggest a "direct cause of death" from hypothermia, they cannot simply be diagnosed as death due to hypothermia. It is important to consider the reason for having such a low temperature at the time of death. Police investigations and toxicological examinations are necessary to determine both “cause of death” and “manner of death”. Death due to hypothermia may differ with respect to the manner of death. For example, if someone is drugged with sleeping pills and is left in a cold place, the manner of death is murder. If someone develops prolonged diseases such as diabetic coma, hepatic encephalopathy, uremia, or cerebral infarction in a cold place and dies, it is a natural death. Furthermore, an accidental death occurs if the femur fractures in a fall or a traffic accident in a low-temperature environment, which first makes the patient non-ambulatory and then leads to death. In cold regions, caution is required because many elderly people die of hypothermia after injuries such as a femoral neck fracture that occur after a fall, even when staying indoors in the winter.

Image findings

Postmortem CT findings associated with hypothermia have been compared with autopsy results [1-4]. Currently, no unified diagnostic criteria for hypothermia in the corpse have been established, which should be carefully evaluated when the following findings are detected on postmortem CT.

Preserving the aerated region of the lungs

A phenomenon called “blood hypostasis”, in which the attenuation of the lung field due to gravity

appears to increase, or pulmonary edema which occurs during the agonal period, is usually observed in postmortem images regardless of the cause of death [5]. However, if death is caused by hypothermia, the findings are mild, and the characteristic feature is that the aerated region is maintained as in the CT image of a living person. A report measured the volume of CT value range (-1,000 to -700 HU) close to the air in the lung and calculated its ratio to the total lung volume. In the hypothermia group, the volume of CT range near air is reported to be significantly larger than that of other causes of death [1]. Similarly, hypothermia is reported to have significantly less elevated lung attenuation compared with other causes of death [2-4]. However, the above lung findings are not specific to hypothermia. Other postmortem cases such as dehydration, starvation, blood loss due to trauma, neck hanging, or obstructive pulmonary disease should be considered differential diagnoses when postmortem CT with air retention in the lung field is observed [2, 6].

In animal experiments, the aerated region of the lung is maintained in a wider range in the hypothermia group than in the non-hypothermia group up to 36 hours after death [7]. It has been reported that 48 hours after death, the lung concentration increases in the hypothermia group, which is not significantly different from that in the non-hypothermia group [7]. The environmental temperature after death in this experiment is 20 degrees Celsius, and it is considered that this phenomenon slows down when the environmental temperature is low and occurs earlier when it is high [7]. Considering this result, even in hypothermia patients, it is highly possible that the lung concentration will increase due to postmortem changes such as blood hypostasis in the lungs 2-3 days after death. Therefore, it is necessary to fully consider both postmortem interval and postmortem changes when evaluating lung CT findings.

Intravascular clot

In postmortem CT, high attenuation bodies are often found in cases with a long agonal period (prolonged death) [8, 9]. This finding is usually observed 2 to 6 hours after death and is observed in the heart and large blood vessels as “template” structure such as a pulmonary artery thrombus [8, 9]. In one study, postmortem CT showed that the number of high attenuation bodies was significantly higher in the hypothermia group than in the non-hypothermia group [3]. However, the high attenuation body was not a specific finding for hypothermia because it is often found in cases of prolonged (non-acute) death such as intracranial hemorrhage, toxic poisoning, infectious disease, or malignant tumor [10].

Bladder urine volume

It is known that a large amount of urine is often found in the bladder of hypothermia patients [3], and it is considered to be caused by the long time leading to death and diuresis due to hypothermia. However, even in cases of hypothermia, there may be little urine in the bladder because of incontinence

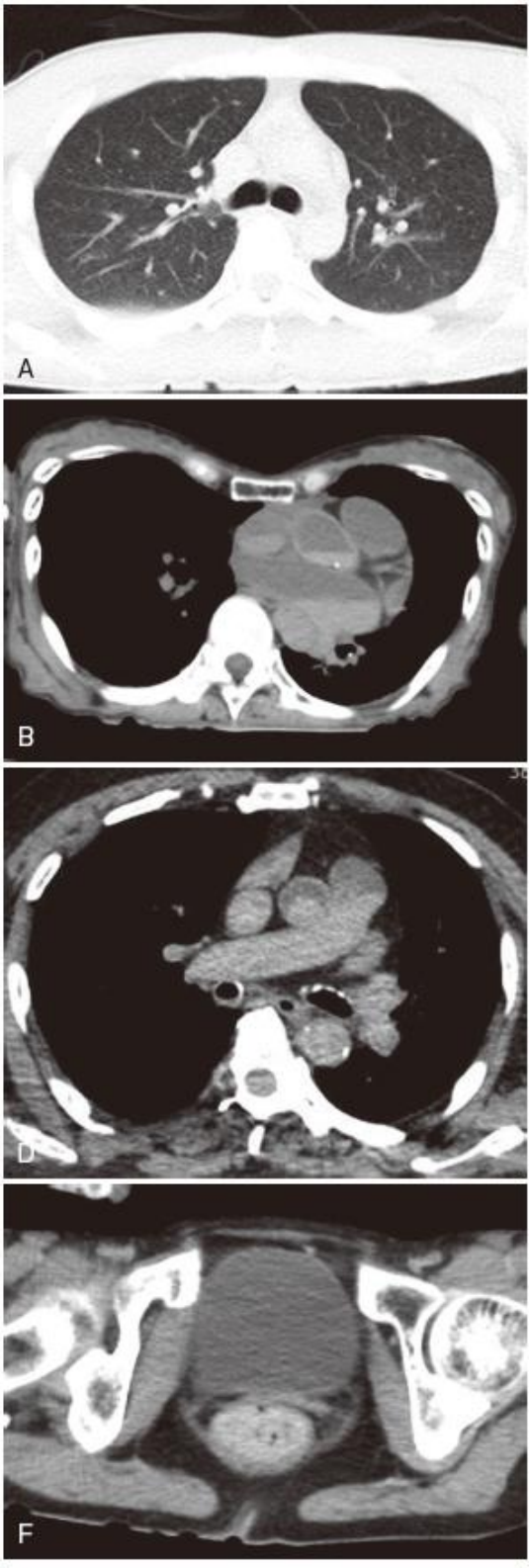
in the agonal period. Therefore, when assessing the amount of urine in the bladder, it is necessary to check the presence and extent of incontinence with an investigative agency that understands the condition of the site and clothing.

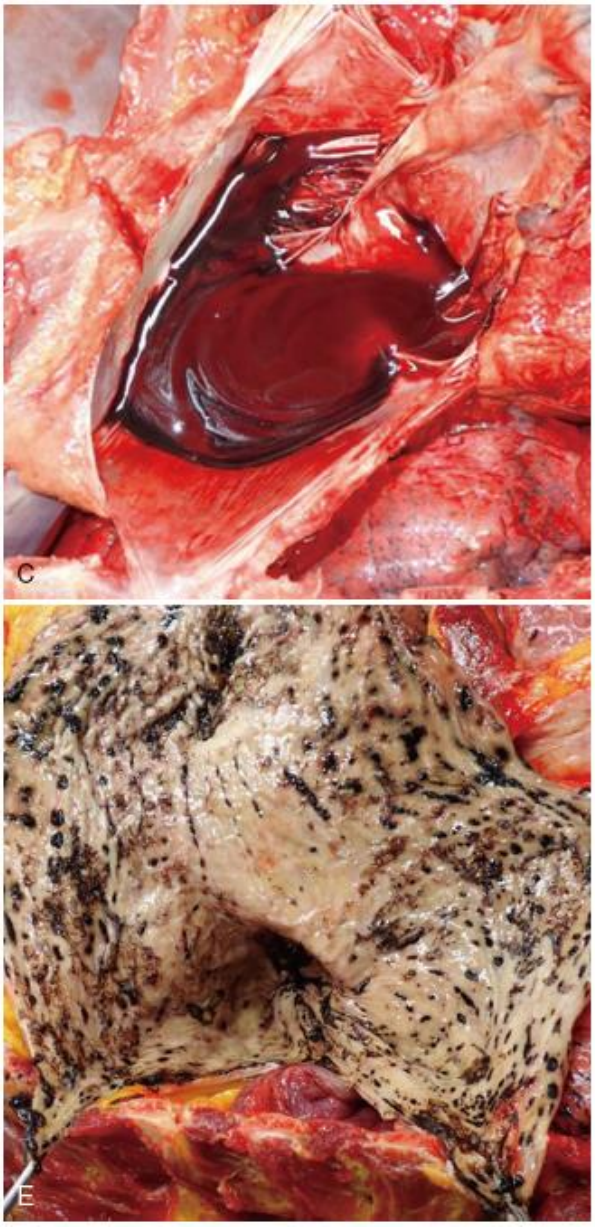
Column----------

In hypothermia cases within 1-2 days after death in a cold environment such as below freezing temperatures, the blood in the heart and aorta often remains fluid without coagulation. In such cases, hypothermia may form a horizontal plane of blood that is generally associated with findings of sudden death on postmortem CT.

Figure Hypothermia

A and C Male in the 50s, B and F Female in the 70s, D and E Male in the 60s





Postmortem CT shows high lung permeability, which is similar to that of a living body (A). In the early postmortem period, horizontal plane formation was observed in the left and right atriums and in the ascending aorta (B), indicating blood fluidity in the heart chamber. During autopsy, if blood in the heart chamber is collected and left at room temperature, the phenomenon of coagulation similar to that of living blood is observed. A difference in the color of the blood in the left and right heart chambers, which is a characteristic finding of

hypothermia, is usually observed in autopsy (C). In the deceased, several days after the latter half of death, blood clots are often found inside the heart and aorta (D). In hypothermia, gastric mucosal hemorrhagic spots (Wischnewski spots) are one of the characteristic findings, and many black spots are often found on the gastric mucosal surface by autopsy (E). However, it is difficult to visualize on postmortem CT. Usually a relatively large amount of urine accumulates in the bladder (F). See column.

Literature search formula and literature selection (2019/8/16)

PubMed

#	Search formula	Number of documents
1	Search (((((postmortem CT) OR postmortem MR) OR postmortem imaging) OR post-mortem CT) OR post-mortem MR) OR postmortem imaging	22,833
2	Search (#4) AND hypothermia	50

Ichushi（Medical Journal）

#	Search formula	Number of documents
1	死後 Ct/AL	450
2	死後 MR/AL	23
3	死後画像/AL	184
4	#1 or #2 or #3	630
5	(低体温症/TH or 低体温/AL)	14,541
6	(凍死/TH or 凍死/AL)	219
7	#5 or #6	14,701
8	#4 and #7	8

From other than search formula

[9, 10]

References

[1] Hyodoh H et al: Postmortem computed tomography lung finding in fatal of hypothermia. Forensic Sci Int 2013; 231: 190-194 (Level 4b)

[2] Michiue T et al: Quantitative analysis of pulmonary pathophysiology using postmortem computed tomography with regard to the cause of death. Forensic Sci Int 2012; 220: 232-238 (Level 4b)

[3] Kawasumi Y et al: Hypothermic death：possibility of diagnosis by post-mortem computed tomography. Eur J Radiol 2013; 82: 361-365 (Level 4b)

[4] Schweitzer W et al: Postmortem pulmonary CT in hypothermia. Forensic Sci Med Pathol 2014;

10: 557-569 (Level 4b)

[5] Shiotani S et al: Non-traumatic postmortem computed tomographic (PMCT) findings of the lung. Forensic Sci Int 2004; 139: 39-48 (Level 4b)

[6] Matoba K et al: Estimating normal lung weight measurement using postmortem CT in forensic cases. Leg Med 2017; 29: 77-81 (Level 4b)

[7] Hyodoh H et al: Postmortem computed tomography findings in the thorax: experimental evaluation. Leg Med 2016; 19: 96-100 (Level 4b)

[8] O'Donnell C et al: Post-mortem radiology: a new sub-specialty? Clin Radiol 2008；63：1189-1194 (Level 4b)

[9] von Both I et al: Differentiation of antemortem pulmonary thromboembolism and postmortem clot with unenhanced MRI: a case report. Forensic Sci Med Pathol 2018; 14: 95-101 (Level 5)

[10] Uekita I et al: Medico-legal investigation of chicken fat clot in forensic cases: immunohistochemical and retrospective studies. Leg Med 2008; 10: 138-142 (Level 4b)