CQ48. What Postmortem Imaging Findings Are Useful for the Evaluation of Hypothermia?

Recommendation Grade

General Assessment: C1

Determination of Cause of Death: C2

In postmortem CT, the following findings may suggest the possibility of hypothermia: preservation of aerated lung regions, presence of postmortem intracardiac or great vessel thrombi appearing as cast-like cylindrical high-attenuation structures, and marked urinary retention in the bladder.

Explanation

● Background

Hypothermia is a fatal condition in which vital functions decline due to a drop in core body temperature caused by cold exposure. It can be a direct cause of death. Autopsy findings associated with hypothermia include Wischnewski spots (hemorrhagic erosions of the gastric mucosa), color differences between blood in the right and left sides of the heart, soft thrombi or pale gelatinous clots in the heart and great vessels, lungs without pulmonary edema, and marked urinary retention.

However, these findings only suggest that hypothermia may have been the direct cause of death and are not sufficient to establish a definitive diagnosis. To determine the underlying cause of death or manner of death, it is essential to consider investigative findings by law enforcement and toxicological analyses, as well as to evaluate the circumstances that led to the exposure to a cold environment.

For example, if an individual was given sedatives and abandoned in a cold area, the case would constitute homicide. If exposure to cold occurred due to immobility from conditions such as diabetic coma, hepatic encephalopathy, uremia, or cerebral infarction, the death would be classified as natural. If hypothermia occurred following a fall or traffic accident in a cold environment, it would be classified as accidental death. In cold climates, special attention should be paid to elderly individuals who suffer femoral neck fractures from indoor falls during winter and subsequently die from hypothermia.

● Imaging Findings

In recent years, several studies have compared autopsy results with postmortem CT findings to investigate characteristic imaging features associated with hypothermia[1–4]. However, a standardized diagnostic criterion for determining hypothermia in deceased individuals based on such imaging findings has yet to be established. Therefore, how to interpret these findings when present remains an open question.

● Preservation of Aerated Lung Regions

The phenomenon known as "dependent density"—an increase in CT attenuation in the dependent portions of the lung—and agonal pulmonary edema are commonly observed postmortem imaging

findings regardless of the cause of death[5]. However, in hypothermic deaths, these findings tend to be mild, and the lungs retain aerated regions similar to those seen in antemortem imaging. It has been reported that the lung volume within the CT attenuation range close to that of air (−1,000 to −700 HU), and its proportion relative to the total lung volume, is significantly higher in the hypothermia group compared to other causes of death[1]. Likewise, several studies have demonstrated that hypothermic deaths exhibit significantly less increase in pulmonary attenuation values compared to other death categories[2–4]. However, such lung findings are not specific to hypothermia and may also be observed in other conditions such as dehydration, starvation, hemorrhagic shock due to trauma, hanging, and obstructive pulmonary diseases[2 6].

An animal study using rabbits reported that the aerated lung regions in the hypothermia group were preserved more extensively up to 36 hours postmortem compared to the non-hypothermic group, but the CT values increased and the difference became insignificant at 48 hours postmortem[7]. In that study, the postmortem environmental temperature was 20°C. It was hypothesized that lower ambient temperatures delay the rise in CT attenuation, whereas higher temperatures accelerate it[7]. Considering these findings, even in hypothermic deaths, postmortem changes such as pulmonary hypostasis may cause an increase in lung CT values after approximately 2 to 3 days. Therefore, when evaluating postmortem lung CT findings, it is essential to consider both the postmortem interval and postmortem changes.

● Intravascular Postmortem Clots

In prolonged deaths with an extended agonal phase, postmortem CT often reveals cylindrical high-attenuation structures—described as “cast-like”—within the heart chambers and great vessels, resembling pulmonary emboli, typically seen 2 to 6 hours after death[8 9]. These structures correspond to the so-called “soft clots” or “chicken fat clots” observed during autopsy. One study reported that such high-attenuation structures were significantly more frequent in the hypothermia group than in the non-hypothermia group on postmortem CT[3]. However, it should be noted that similar findings are also commonly observed in prolonged deaths due to intracranial hemorrhage, acute drug or toxic substance intoxication, infections, and malignancies, and therefore this finding is not specific to hypothermia[10].

● Urinary Retention in the Bladder

It is well known that in cases of hypothermia, a large volume of urine is often observed in the bladder[3]. This is thought to result from a prolonged dying process and hypothermia-induced diuresis. However, even in hypothermia cases, the bladder may contain little to no urine due to urinary incontinence during the agonal phase. Therefore, when evaluating urinary retention in the bladder, it is essential to consult investigative authorities regarding the presence or degree of incontinence based on findings at the scene or the condition of the clothing.

Column: Hypothermia in Subzero Environments

In subzero environments, the agonal period leading to death from hypothermia tends to be shorter, and postmortem changes are significantly suppressed (coagulation ability of the blood is preserved). Therefore, even in hypothermia cases, when the postmortem interval is relatively short (approximately within 1–2 days), blood in the heart and aorta often remains uncoagulated and fluid. As a result, postmortem CT of the chest may show a horizontal fluid level, which is generally considered a finding suggestive of sudden death.

○ Literature Search Strategy and Selection (November 9, 2023)

【PubMed】

#	Search formula	Number of articles
1	Search (((((postmortem CT) OR postmortem MR) OR postmortem imaging) OR post-mortem CT) OR post-mortem MR) OR post-mortem imaging	29,173
2	Search (#4) AND hypothermia	61

【医中誌 Ichushi-Web (Japan Medical Abstracts Society Database)】

#	Search formula	Number of articles
1	死後 Ct/AL	564
2	死後 MR/AL	29
3	死後画像/AL	221
4	#1 or #2 or #3	777
5	(低体温症/TH or 低体温/AL)	15,890
6	(凍死/TH or 凍死/AL)	309
7	#5 or #6	16,139
8	#4 and #7	9

●Additional Sources Not Captured by the Search Strategy

References［9］, ［10］

■References

1) Hyodoh H et al：Postmortem computed tomography lung findings 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-speciality? 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）

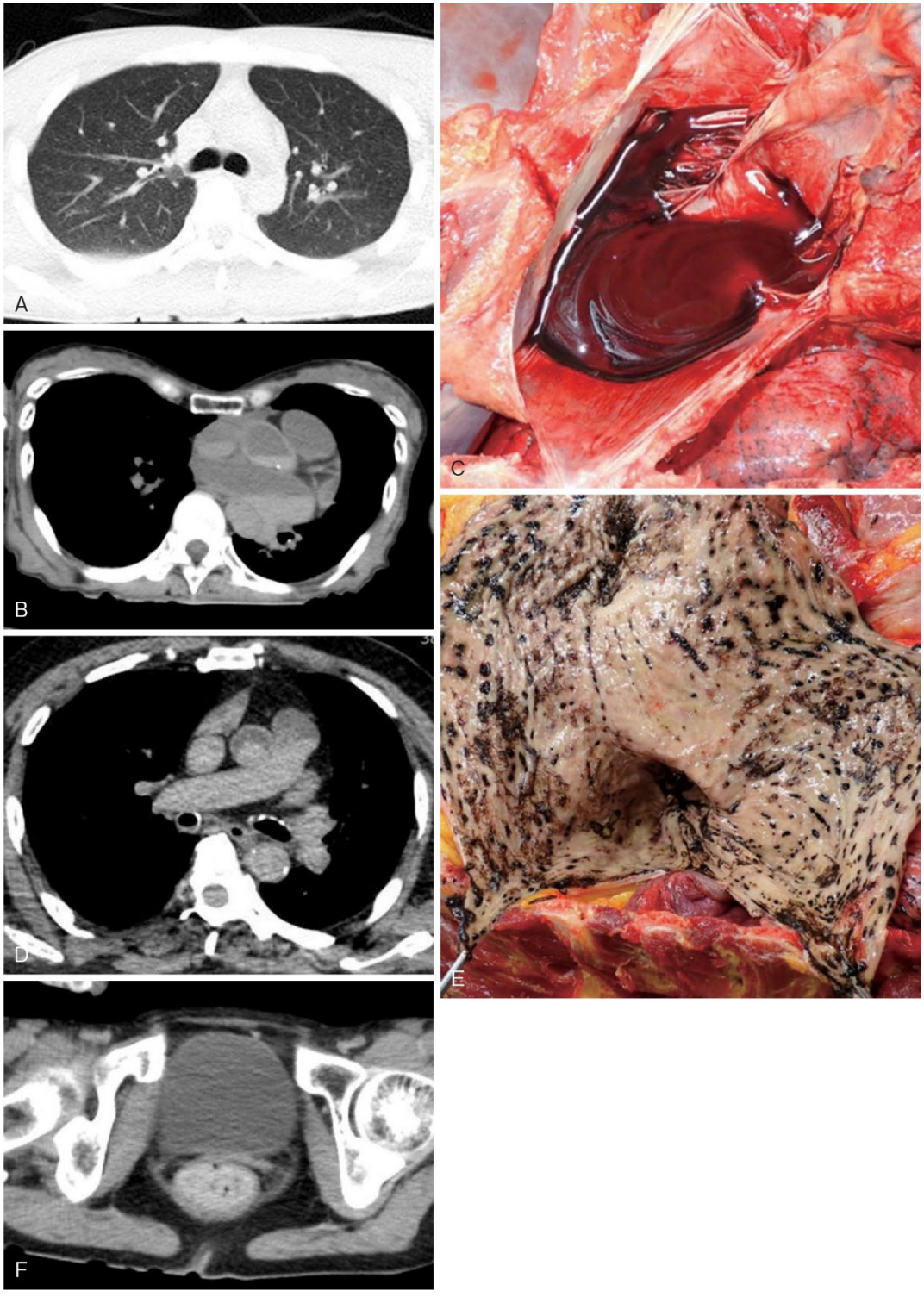

Figure: Hypothermia

A, C: Male in his 50s B, F: Female in her 70s D, E: Male in his 60s

Postmortem CT shows well-preserved aerated lung fields resembling those seen in the living body (A).

In the early postmortem period, horizontal layering suggestive of fluid blood can be seen in the left and right atria and ascending aorta on CT (B). When cardiac blood is collected during autopsy and left at room temperature, it coagulates similarly to blood from the living. A characteristic autopsy finding of hypothermia—color difference between the blood in the left and right heart chambers—can be observed (C). In cases with a postmortem interval of half a day to several days, cast-like clots are often seen in the heart and aorta (D). Gastric mucosal hemorrhages (Wischnewski spots), another typical finding of hypothermia, are often identified during autopsy (E), though difficult to visualize on postmortem CT. The bladder often contains a relatively large amount of urine (F). See column for details.