CQ39 What are useful findings in postmortem images to determine drowning?

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

Postmortem CT findings for drowning victims frequently show fluid retention in the paranasal sinuses, fluid retention and high absorption in the respiratory tract, ground glass opacity in the lungs, fluid retention in the pleural cavity, and fluid retention and dilation in the digestive tract such as of the stomach. However, these findings are not specific to drowning, and it is necessary to carefully refer to other tests to confirm the cause of death.

Explanation----------

Background

Drowning is a type of suffocation caused by aspiration of liquid into the respiratory tract, causing impaired gas exchange in the alveoli. Although the mechanism differs depending on whether the medium is fresh water or seawater, in either case the changes in circulating blood volume, hemolysis, fatal arrhythmia due to electrolyte abnormality, and circulatory insufficiency due to heart pump failure contribute to the cause of death.

It is important to diagnose whether the cause of death of an immersed body is drowning or if there is another cause of the death. Even if drowning is shown by a forensic autopsy, it often cannot determine the cause of the drowning. A definite diagnosis of drowning can be difficult even by a forensic autopsy [1]. During an autopsy of a drowning victim, a large amount of small white foam-like bubbles in the airway from the nasal/oral cavity to the bronchus, a pulmonary bulge and aqueous emphysema, aqueous pulmonary edema on the fissure surface, and a large amount of fluid retention in the digestive tract of the stomach, and other signs can be observed early after death. Although the findings differ depending on the ambient temperature, the fine bubbles in the respiratory tract decrease in volume or disappear entirely and a large volume of liquid is observed in the pleural cavity due to leakage of the liquid aspirated into the lungs 1 to 2 days after death. Furthermore, detection of plankton in various organs and electrolyte tests of the pleural cavity fluid and sphenoid sinus fluid are considered useful for a diagnosis of drowning [2, 3].

Postmortem CT findings with drowning

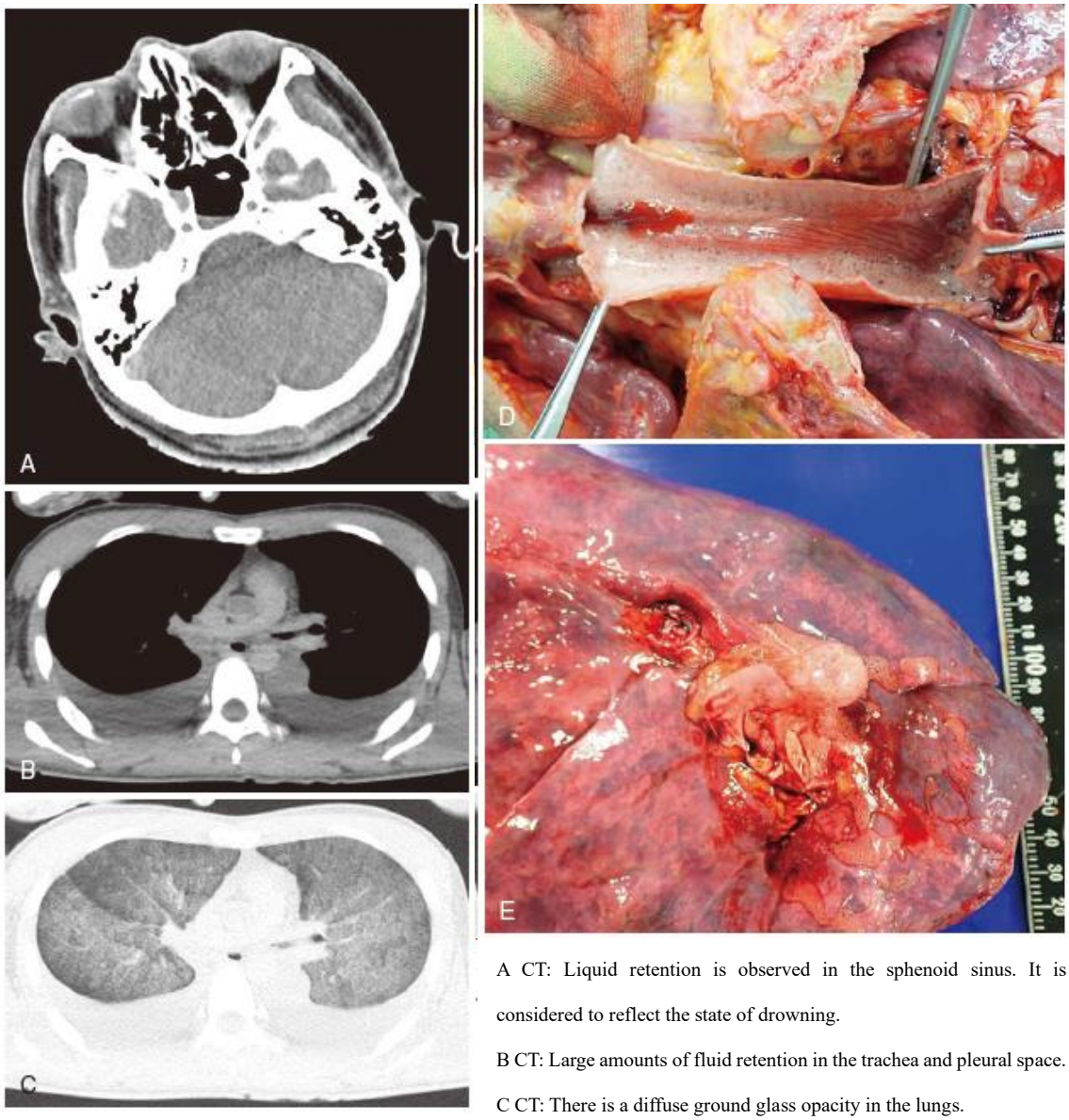
Postmortem CT image findings in drowning cases are characterized by the following findings [4-8]: sinus and airway fluid retention and high attenuation sediments, foamy content in the airways, ground glass opacity in the lungs, pleural cavity fluid retention, and a large volume of fluid retention and

expansion in parts of the digestive tract such as in the stomach. It was reported that liquid retention in the mastoid air cell has been observed in drowning [4], but recently it was observed only in about 10% of cases of drowning victims [7, 8]. High attenuation sediment and foamy contents in the respiratory tract are specific findings in cases of drowning. If the above findings are identified, drowning may be positively suspected [4]. There was, however, also a report that fine white air bubbles in the respiratory tract detected by the autopsy were not visualized by the postmortem CT examination [9]. In addition, it is reported that foamy contents in the respiratory tract may be observed in suffocation cases due to causes other than drowning, and the frequency of detection is not significantly different from drowning [7]. The high attenuation sediment in the respiratory tract is a visualization of sand particles contained in the aspirated liquid and, although its specificity is high, its positive frequency of determination depends on the properties of the inhaled liquid. Liquid retention in the respiratory tract, including in the paranasal sinuses, has been observed in drowning victims but, because the inside of the respiratory tract is an open cavity, consideration should be given to the possibility of passive fluid infiltration after death. Therefore, it is necessary to confirm the conditions of the place of entry and the site of discovery, water depth, drift distance, and the condition of water flow and waves with the investigative authorities.

As a distinction from pulmonary edema due to circulatory insufficiency other than drowning, it has been reported that the ground glass opaque appearance of the lungs in drowning exhibits a characteristic mosaic pattern [4, 5]. In addition, there are reports that reduced distance in the anterior mediastinum of the left and right lungs is regarded as a characteristic finding in lung distension [9]. However, it has also reported that these findings did not show statistically significant differences between drowning and non-drowning suffocation [7], and these findings should be limited to an ancillary diagnosis. To date, reports of postmortem CT image findings in drowning cases have been studied for cases without putrefaction (within a 1 to 2 days postmortem interval). For this reason, the above findings are often not observed in corpses that have undergone postmortem changes.

In recent years, 2 postmortem CT examinations in single drowning cadavers (before inspection and before autopsy) reported that postmortem CT findings made before the autopsy showed increased pleural fluid retention and decreased lung absorption (increase in absorbed air areas) compared with postmortem CT findings made before inspection [10]. Animal experiments have demonstrated that drowning causes liquid retention in the pleural cavity about 12 to 36 hours after death, and increases the proportion of the aerated region (-1,000 to -700 HU) in the lungs 36 hours after death. It is considered that the water aspirated into the lungs during drowning leaks into the pleural cavity due to postmortem changes after some period, and that the fluid accumulates there. Therefore, it should be noted that lung field findings may change following the early postmortem period. Although postmortem CT image findings have been able to distinguish drowning in freshwater from drowning in seawater [12, 13], there is also a report that does not show a significant difference in such victims [14]. Further studies are needed to reach a definitive conclusion.

Figure 1, Male in the 20s, sea water drowning (2 days after death)



A CT: Liquid retention is observed in the sphenoid sinus. It is considered to reflect the state of drowning.

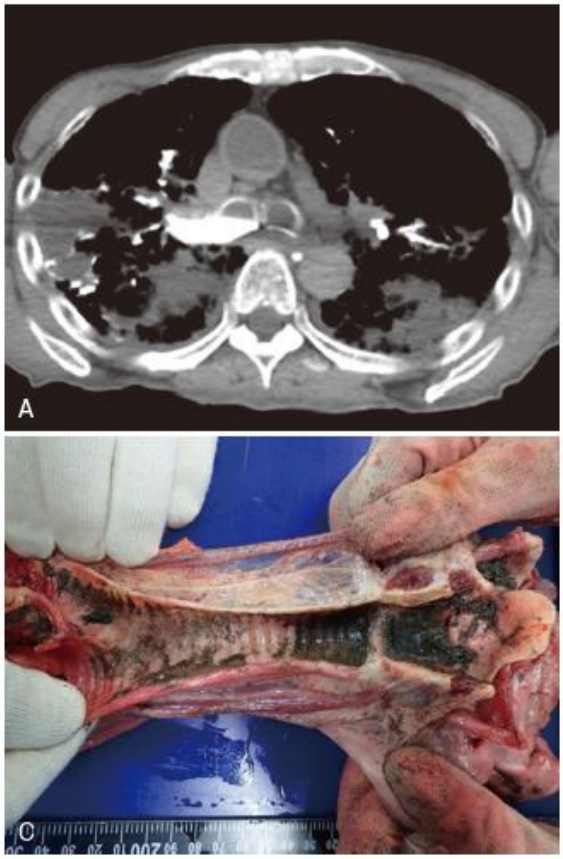
B CT: Large amounts of fluid retention in the trachea and pleural space.

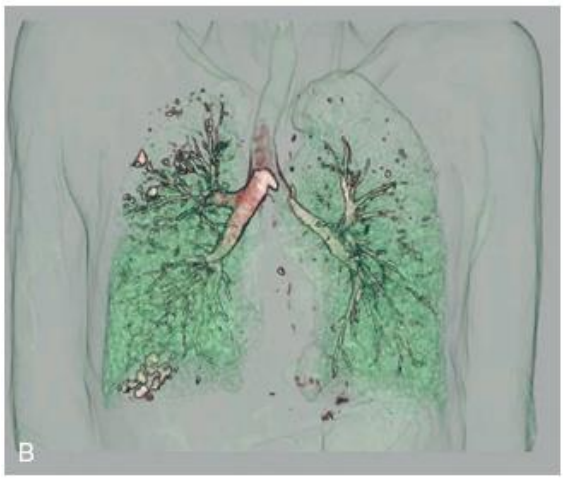
C CT: There is a diffuse ground glass opacity in the lungs.

D Autopsy macroscopic findings: A large amount of fine white foam is observed in the trachea.

E Autopsy macroscopic findings: Large amounts of foam flowed out from the bronchial stump.

Figure 2, Male in the 70s, discovered being washed up on the coast (2 days after death).



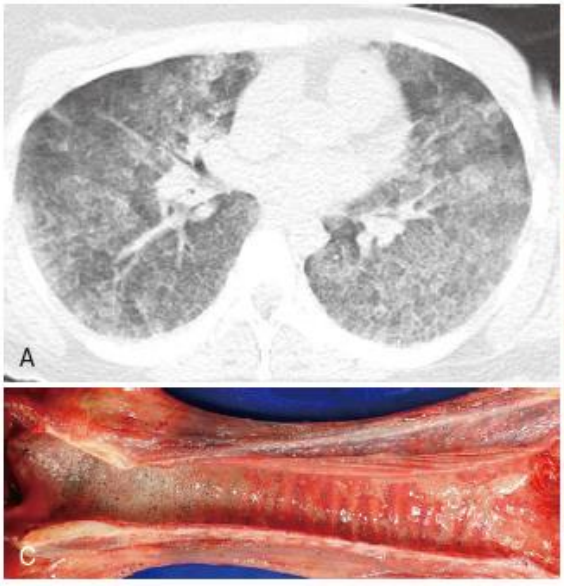


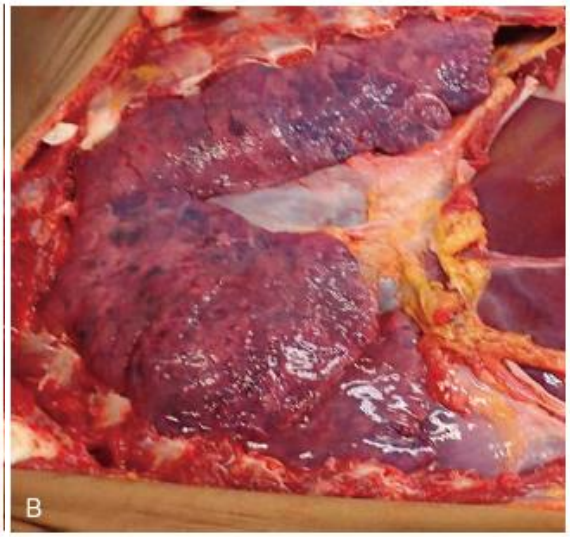
A CT: A high attenuation structure is visible in the bronchus, and liquid is observed at the carina.

B VR image: The high attenuation structure in the trachea extends to the peripheral lung.

C Autopsy macroscopic findings: Adhesion of sand grains is observed in the trachea.

Figure 3, Female in the 30s, fresh water drowning (1 day after death)





A CT: A diffuse lung ground glass opacity, not affected by gravity, is observed.

B Autopsy macroscopic findings: The lungs are swollen and the medial edges of the left and right lungs overlap at the anterior mediastinum. Hemorrhagic spots (Paltauf *s*pots) can be identified on the visceral pleura.

C Autopsy macroscopic findings: A large amount of fine white foam is observed in the trachea.

Literature search formula and literature selection (2019/8/30)

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 post-mortem imaging	22,833
2	Search drowning	5,725
3	Search (#4) AND #5	79

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	((溺水/TH or 溺水/AL)) and ((PT= 症例報告, 事例) AND (PT= 原著論文, 解説, 総説, 図説,Q ＆ A, 講義))	270
6	#4 and #5	5

References

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[2] Matoba K et al: Application of electrolyte analysis of pleural effusion to diagnosis of drowning. Leg Med 2012; 14: 134-139 (Level 4b)

[3] Yajima D et al: Diagnosis of drowning by summation of sodium, potassium, and chloride ion levels in sphenoidal sinus fluid: differentiating between freshwater and seawater drowning and its application to brackish water and bathtub deaths. Forensic Sci Int 2018; 284: 219-225 (Level 4b)

[4] Levy AD et al: Virtual autopsy: two- and three-dimensional multidetector CT findings in drowning with autopsy comparison. Radiology 2007; 243: 862-868 (Level 4b)

[5] Christe A et al: Drowning: post-mortem imaging findings by computed tomography. Eur Radiol 2008; 18: 283-290 (Level 4b)

[6] Usui A et al: Postmortem lung features in drowning cases on computed tomography. Jpn J Radiol 2014; 32: 414-420 (Level 4b)

[7] Van Hoyweghen AJ et al: Can post-mortem CT reliably distinguish between drowning and non-drowning asphyxiation? Int J Legal Med 2015; 129: 159-164 (Level 4b)

[8] Vander Plaetsen S et al: Post-mortem evaluation of drowning with whole body CT. Forensic Sci Int 2015; 249: 35-41 (Level 4b)

[9] Watanabe S et al: Postmortem CT images and autopsy findings: Examination of 5 autopsy cases showing pulmonary edema. The Research and Practice in Forensic Medicine 2009; 52: 25-33 (Level 5) (Japanese)

[10] Hyodoh H et al: Time-related course of pleural space fluid collection and pulmonary aeration on postmortem computed tomography (PMCT). Leg Med 2015; 17: 221-225 (Level 4b)

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

[12] Kawasumi Y et al: Distinction between saltwater drowning and freshwater drowning by assessment of sinus fluid on post-mortem computed tomography. Eur Radiol 2016; 26: 1186-1190 (Level 4b)

[13] Sugawara M et al: Postmortem computed tomographic features in the diagnosis of drowning: a comparison of fresh water and salt water drowning cases. Jpn J Radiol 2019; 37: 220-229 (Level 4b)

[14] Hyodoh H et al: Experimental drowning lung images on postmortem CT: difference between sea water and fresh water. Leg Med 2016; 19: 11-15 (Level 4b)