CQ07 Is it possible to detect and quantify body gas using postmortem images?

Grades of recommendations:
B for evaluating status
C1 for cause of death determinations

Postmortem CT can detect abnormal gases in various parts of the body. At an autopsy, the gas in the body moves or is released into the atmosphere and disappears. Postmortem CT can more easily detect the presence of body gas than an autopsy, and can show the distribution of gas in the body. It is also possible to measure the gas volume using image analysis software with CT. Intravascular gas mainly occurs due to postmortem changes and/or cardiopulmonary resuscitation, but it is also generated by exogenous air embolism. Therefore, where the clinical course is unknown, the cause must be carefully determined based on the distribution and the amount of gas, as well as the time that has elapsed since death. Gas in body cavities, such as in the thoracic or abdominal cavity, appears as postmortem changes (autolysis and putrefaction), and it must be distinguished from gas related to antemortem trauma and diseases. The longer the postmortem interval, the more commonly body gases are detected; however, the time that has elapsed since death is difficult to estimate based on the gas volume.

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

Postmortem CT detects gas retention in various parts of the body [1-27]. Postmortem CT clearly delineates digestive tract gas, organ parenchymal (and/or intravascular) gas such as in the brain, liver, kidneys, spleen, and pancreas; intravascular gas as in the aorta, cardiac chambers, and coronary arteries, and intracavital gas as in the cranial cavity, thoracic cavity including mediastinal space and the pleural cavity, peritoneal cavity, and retroperitoneal cavity.

Regarding non-traumatic death cases

The causes of intravascular gas generation in non-traumatic death cases are the effects of cardiopulmonary resuscitation (CPR) or putrefaction of the body [1-27].

Correlations have been reported between gas retention in organs and cardiopulmonary resuscitation [2,6,7,11,13-15, 22, 25], and this may help determine the cause of gas identified in the body. For the presence of intracranial gas, cardiovascular gas generated by cardiopulmonary resuscitation flows retrogradely into the cerebral vein [11]. Intravascular gas distributed throughout the body is observed in cases of prolonged CPR (those conducted for many hours) [14].

The gas showing in vessels on postmortem CT within a few hours after death is considered to be carbon dioxide [25]. This may be the result of mixed acidosis as a mixture of lactic acidosis at the time

of cardiopulmonary arrest (shock → anaerobic metabolism → lactate + H^+ rise causes the bicarbonate buffer system to promote $H^+ + HCO_3^- \rightarrow CO_2 + H_2O$) and respiratory acidosis (decreases in carbon dioxide excretion from the lungs → increases in carbon dioxide amount). This specifically increases the carbon dioxide concentration in the veins, leading to the appearance of carbon dioxide as gas that cannot be dissolved in blood [26].

Postmortem changes begin shortly after death. On postmortem CT, the occurrence of putrefaction is shown starting from intravascular retention of gas to intraparenchymal gas in the organs. The putrefaction process can be approximately classified into early, middle, and late phases [8]. In the early phase of putrefaction, gas is mainly observed in the heart (especially on the right side of the heart) and in hepatic vessels. The second most common place for gas to appear is in the intra-mesenteric vessels. The putrefaction gas volume increases with the postmortem interval, and the gas volume gradually increases even when the corpse is stored in a refrigerator [5]. The effect of putrefaction should be considered when body gas is identified in corpses after a long postmortem interval. The frequency of body gas detection increases with time elapsed since death; however, it is difficult to estimate the postmortem interval based on the volume of gas, because the presence of gas is markedly affected by the specific conditions and environments the body has been maintained in.

Free gas in the abdominal cavity is useful as an indirect finding of digestive tract perforation [10, 12]; however, gastric perforation due to autolysis (gastromalacia) may be shown on postmortem CT; for this reason, caution must be shown when making the diagnosis. If there are no image findings of putrefaction or peritonitis on postmortem CT, the presence of peritoneal free gas may be due to gastric perforation as a postmortem change [10].

Extrinsic or trauma death except with decompression disorders

In incidents (involving criminality) or accidents, where gas (air or oxygen) has been artificially injected into a blood vessel, postmortem CT was reported to have clearly identified gas in vessels throughout the body, subcutaneous gas, as well as gas in body cavities including, intrathoracic (mediastinum and pleura), abdominal, and retroperitoneal cavities [23, 24]. Reconstructed CT facilitates an evaluation of the overall findings, and also makes it possible to quantify the gas volume [1, 24]. Gas injection into arteries or veins of the extremities may cause air embolisms, which may lead to death, depending on the injected volume and rate of injection [3, 13], although this may be difficult to determine based solely on CT findings.

In cases of trauma death, the formation of a trauma fistula between the alveoli and pulmonary vein has in many cases been reported as the main cause of arterial air embolisms after chest trauma [16]. Further, head and neck trauma have been reported to cause venous air embolisms [1]. When there is a right-left shunt as with a patent foramen ovale or a pulmonary arteriovenous fistula, intravenous gas may flow into the systemic circulation and cause arterial air embolisms (paradoxical embolism) [23,

24]. These arterial air embolisms may be a cause of death, and detection of intravascular gas can help estimate the cause of death.

Decompression disorders are described in Section CQ46.

Literature search formula and literature selection（2019/6/18）

PubMed

1) About gas in postmortem image

#	Search formula	Number of documents
1	Search((("postmortem CT")OR "postmortem imaging")OR "postmortem CT")OR "post-mortem imaging"	22,259
2	Search(#1)AND "gas"	288
3	Search(#2)NOT "diving"	265

2) About airs in postmortem image

#	Search formula	Number of documents
1	Search((("postmortem CT")OR "postmortem imaging")OR "postmortem CT")OR "post-mortem imaging"	22,259
2	Search(#1)AND "air"	370
3	Search(#2)NOT "diving"	350

From other than search formula

[3, 12, 15, 22, 26]

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