CQ18: Is postmortem imaging useful for identifying organ injuries caused by cardiopulmonary resuscitation (CPR)?

Recommendation Grade:

Condition Assessment: C1

In non-traumatic deaths, postmortem imaging is useful in detecting organ injuries associated with CPR. There are differences in the frequency and types of organ injuries depending on whether chest compressions were performed manually or with a mechanical compression device. It is important not to misinterpret CPR-related organ injuries as antemortem traumatic injuries during image interpretation.

Explanation

● Background

Cardiopulmonary resuscitation (CPR) for patients in cardiac arrest includes chest compressions performed manually on the anterior chest while the patient is in the supine position.

In recent years, various mechanical chest compression devices have been developed, and their effectiveness has been reported. However, complications associated with these devices have also been documented.

● Imaging Findings

Cardiopulmonary resuscitation (CPR) for cardiac arrest involves chest compressions and positive-pressure ventilation. In some cases, organ injuries resulting from these procedures become apparent after return of spontaneous circulation, and many such cases have been reported[1,2].

There are also reports describing postmortem CT findings of organ injuries caused by CPR. In addition to rib and sternal fractures (see CQ17), reported thoracic findings include pericardial hematoma[2–5], myocardial injury[2], coronary artery injury (including embolism)[2], aortic dissection[2], inferior vena cava injury[2], mediastinal hemorrhage[2], pneumothorax and pneumomediastinum[2,6,7], pleural effusion or hemothorax[2,4], and lung injury[2]. Abdominal findings include liver injury[2,3,6–8]. As the duration of CPR increases, intravascular gas is more frequently observed[9,10], including not only in the blood vessels and hepatic veins[11], but also intracranially[12,13] (see CQ8). Whether such gas enters the vasculature during CPR in non-traumatic deaths or arises postmortem by mechanisms other than putrefaction remains an area of ongoing research.

As for the severity of organ injuries, there appears to be no significant difference between manual chest compressions and those performed using mechanical compression devices[3]. However, liver injuries have been more frequently reported in cases involving mechanical compression devices[3,14–16]. Additionally, intra-abdominal or retroperitoneal hemorrhage and the presence of free intraperitoneal

gas occur significantly more often than in manual compressions[17]. Among these devices, LUCAS® has not been associated with more severe organ injuries compared to manual compressions, whereas AutoPulse® has been reported to cause more severe injuries[14]. The CLOVER3000®, developed to match the physique of Japanese individuals, has shown no significant difference in injury rates compared to manual compressions in reported studies[18].

Of the aforementioned injuries, fractures, intrathoracic gas such as pneumothorax, pericardial hemorrhage, and pleural or peritoneal fluid accumulations can be detected on unenhanced postmortem CT. Findings such as the morphological features of pericardial hemorrhage (see CQ33) and the location of rib fractures (see CQ17) may aid in distinguishing antemortem injuries from those caused by CPR. However, exceptions exist, and careful interpretation is required.

○ Literature Search Strategy and Selection (as of November 7, 2023)

【PubMed】

#	Search formula	Number of articles
1	Search (postmortem CT) OR (postmortem computed tomography)	9,642
2	Search (postmortem MRI) OR (postmortem magnetic resonance imaging)	8,409
3	Search (CPR) OR (cardiopulmonary resuscitation)	39,847
4	Search ((#1) OR (#2)) AND (#3)	89
5	Search (#4) AND (injury)	42

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

#	Search formula	Number of articles
1	(死後 mri/AL) and (PT=原著論文, 会議録除く)	21
2	(死後 ct/AL) and (PT=原著論文, 会議録除く)	263
3	((心肺蘇生法/TH or 心肺蘇生術/AL)) and (PT=原著論文, 解説, 総説, 図説,Q＆A, 講義, 会議録除く)	7,363
4	#1 and #3	1
5	#2 and #3	18

●Additional Sources Not Captured by the Search Strategy

References［1］,［2］,［5］

■References

1） Meron G et al：Cardiopulmonary resuscitation-associated major liver injury. Resuscitation 2007；75：445-453（level 4b）
2） Miller AC et al：A systematic review and pooled analysis of CPR-associated cardiovascular and thoracic injuries. Resuscitation 2014；85：724-731（level 4b）
3) Ondruschka B et al：Chest compression-associated injuries in cardiac arrest patients treated with manual chest compressions versus automated chest compression devices （LUCASII） ― a forensic autopsy-based comparison. Forensic Sci Med Pathol 2018 ； 14 ： 515-525（level 4b）
4） Watanabe S et al：Classification of hemopericardium on postmortem CT. Leg Med 2015；17：376-380（level 4b）
5） Yamaguchi R et al： Fluid-fluid level and pericardial hyperdense ring appearance findings on unenhanced postmortem CT can differentiate between postmortem and antemortem pericardial hemorrhage. AJR Am J Roentgenol 2015 ； 205 ： W568-577（level 4b）
6) Kashiwagi Y et al ： Computed tomography findings of complications resulting from cardiopulmonary resuscitation. Resuscitation 2015；88：86-91（level 4b）
7） Yamaguchi R et al：Frequency and influencing factors of cardiopulmonary resuscitation-related injuries during implementation of the American Heart Association 2010 Guidelines： a retrospective study based on autopsy and postmortem computed tomography. Int J Legal Med 2017 ； 131 ： 1655-1663（level 4b）
8) Pinto DC et al：Manual and automated cardiopulmonary resuscitation（CPR）：a comparison of associated injury patterns. J Forensic Sci 2013；58：904-909（level 4b）
9) Halbertsma FJ et al：Prevalence of systemic air-embolism after prolonged cardiopulmonary resuscitation in newborns：a pilot study. Resuscitation 2015；93：96-101（level 4b）
10) Zenda T et al ： Intravascular gas in multiple organs detected by postmortem computed tomography：effect of prolonged cardiopulmonary resuscitation on organ damage in patients with cardiopulmonary arrest. Jpn J Radiol 2011；29：148-151（level 5）
11) Offiah CE et al：Post-mortem CT and MRI：appropriate post-mortem imaging appearances and changes related to cardiopulmonary resuscitation. Br J Radiol 2016；89：20150851（level 4b）
12) Shiotani S et al：Nontraumatic postmortem computed tomographic demonstration of cerebral gas embolism following cardiopulmonary resuscitation. Jpn J Radiol 2010；28：1-7（level 5）
13) 高橋直也ほか：死後 CT（オートプシー・イメージング）360 例における死後所見・心肺蘇生術所見の検討．臨放 2008；53：1840-1845（level 4b）
14）Koster RW et al：Safety of mechanical chest compression devices AutoPulse and LUCAS in cardiac arrest：a randomized clinical trial for non-inferiority. Eur Heart J 2017；38：3006-3013（level 2）
15）Olds K et al：Injuries associated with resuscitation：an overview. J Forensic Leg Med 2015；

33：39-43（level 4b）
16）Smekal D et al：CPR-related injuries after manual or mechanical chest compressions with the LUCAS TM device：a multicentre study of victims after unsuccessful resuscitation. Resuscitation 2014；85：1708-1712（level 4b）
17）Koga Y et al：Effects of mechanical chest compression device with a load-distributing band on post-resuscitation injuries identified by post-mortem computed tomography. Resuscitation 2015；96：226-231（level 4b）
18）Hayashi M et al：Compression-associated injuries using CLOVER3000 device in non-survivor patients of OHCA： A retrospective cohort study. Am J Emerg Med 2023； 68： 127-131（level 4a）

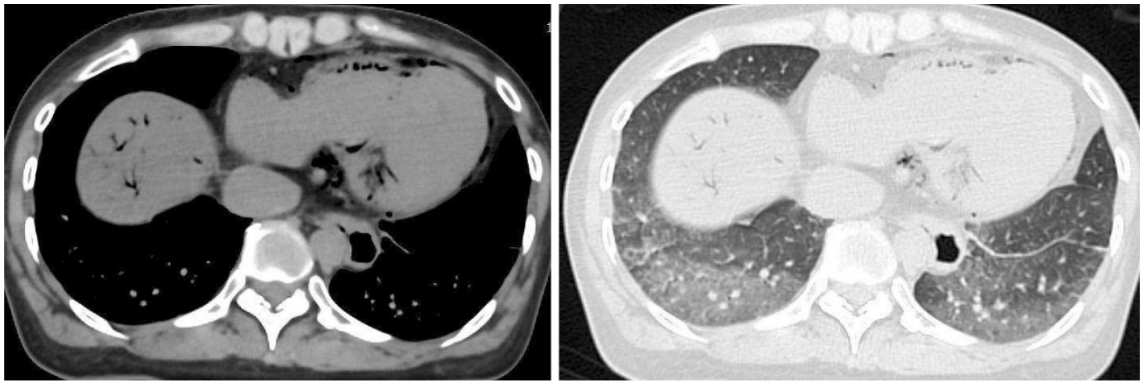

Figure. Woman in Her 40s, Post-Cardiopulmonary Resuscitation

Gas is observed in the anterior wall of the right ventricular cavity and within the liver. A small amount of gas is also present within the myocardial layer of the interventricular septum.