CQ17: Is postmortem imaging useful for identifying rib fractures caused by cardiopulmonary resuscitation (CPR)?

Recommendation Grade: C1

Rib fractures resulting from CPR are often characterized by incomplete fractures known as buckle rib fractures, which are frequently observed on postmortem CT. These fractures are particularly common in elderly individuals and in cases where CPR was performed for long period of time. They typically occur in the anterior one-third of the 2nd to 9th ribs, and their identification can help differentiate CPR-related fractures from those caused by external trauma.

Explanation

● Background

Cardiopulmonary resuscitation (CPR) involves chest compressions to generate cardiac output. Manual chest compressions are recommended to depress the lower part of the sternum by approximately 5 cm[1]. Because this procedure exerts substantial force on the rib cage, rib fractures are frequently observed as a common complication[2–6]. In recent years, mechanical chest compression devices (such as LUCAS® and AutoPulse®) have become more widely used. Similar to manual compressions, rib fractures remain one of the most frequent complications associated with these devices[7–9].

● Imaging Findings

Rib fractures caused by manual chest compressions are often characterized by a type of incomplete fracture known as a *buckle rib fracture*, in which only the inner cortex—or, less commonly, the outer cortex—is disrupted, while continuity is maintained on the opposite side. These fractures are frequently observed on postmortem CT[6]. They are especially common in elderly individuals or in cases where CPR was prolonged[3 5 8]. Most buckle rib fractures occur in the anterior one-third of the 2nd to 9th ribs. In lower ribs such as the 7th to 9th, buckle rib fractures are often seen at the costochondral junction[4 6]. When rib fractures are located in the posterior ribs, below the 9th rib, or when inward bending is observed, the possibility of traumatic injury unrelated to chest compressions should be considered[6].

In comparisons between manual chest compressions and mechanical compressions using devices such as LUCAS or AutoPulse, the frequency of rib fractures is reported to be similar[7 8], or in some reports, higher with manual compressions[9]. Both manual compressions and those performed using LUCAS tend to result in anterior rib fractures, with few fractures in the posterior ribs. In contrast, chest compressions using AutoPulse are associated with a higher incidence of posterior rib fractures[7 9]. Therefore, when diagnosing rib fractures related to chest compressions, it is important to understand the characteristics of the device used and to interpret findings with caution.

In addition to rib fractures, sternal fractures are also frequently observed following chest compressions[2] [3] [5] [6]. These typically involve fractures of the outer cortical bone and are often accompanied by inward deformation or depression[6].

○ Literature Search Strategy and Selection (as of September 17, 2023)

【PubMed】

#	Search formula	Number of articles
1	Search (((((("postmortem CT") OR "postmortem MRI") OR "postmortem imaging") OR "post-mortem CT") OR "post-mortem MRI") OR "postmortem imaging"	1,076
2	Search (#1) AND CPR	22

【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)	262
3	((心肺蘇生法/TH or 心肺心肺蘇生術/AL)) and (PT=原著論文, 解説, 総説, 図説,Q＆A, 講義, 会議録除く)	7,102
4	#1 and #3	1
5	#2 and #3	16

●Additional Sources Not Captured by the Search Strategy

References［1］,［3］,［5］,［7］,［8］,［9］

■References

1） 日本蘇生協議会 編：JRC 蘇生ガイドライン 2020, 医学書院, 2020

2） Ishida M et al：Essence of postmortem computed tomography for in-hospital deaths： what clinical radiologists should know. Jpn J Radiol 2023 ； 41 ： 1039-1050（level 5）

3） Kashiwagi Y et al ： Computed tomography findings of complications resulting from cardiopulmonary resuscitation. Resuscitation 2015；88：86-91（level 4b）

4） Offiah CE, Dean J：Post-mortem CT and MRI： appropriate post-mortem imaging appearances and changes related to cardiopulmonary resuscitation. Br J Radiol 2016 ； 89（1058） ： 20150851（level 5）

5） 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）

6) Yang KM et al："Buckle" rib fracture： an artifact following cardio-pulmonary resuscitation detected on postmortem CT. Leg Med 2011 ； 13 ： 233-239（level 4b）

7） Koga Y et al：Effects of mechanical chest compression device with a load-distributing band on postresuscitation injuries identified by post-mortem computed tomography. Resuscitation 2015 ； 96 ： 226-231（level 4b）

8） 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）

9） 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）

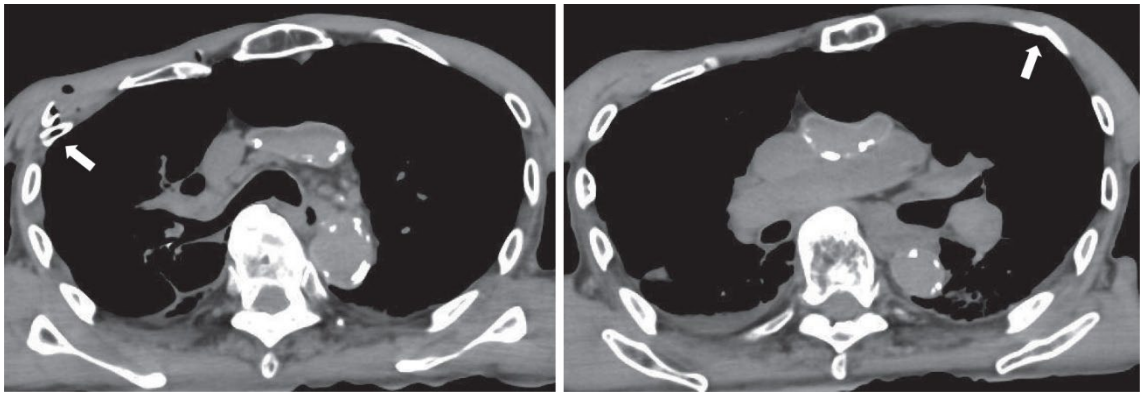

Figure 1: Male in his 60s

Rib fractures on both sides caused by resuscitation efforts (⇨).

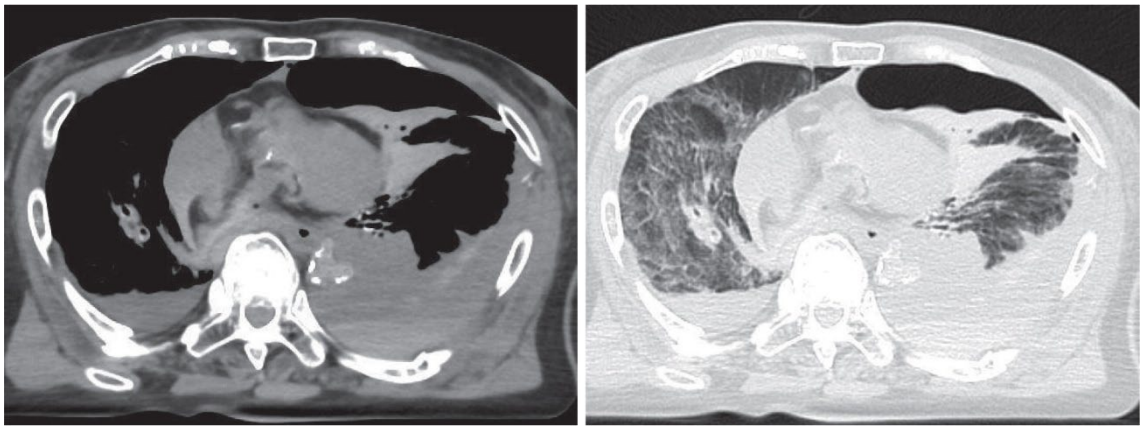

Figure 2: Female in her 80s, fall

A left-sided pneumothorax is observed. There is fluid accumulation in both pleural cavities, with a marked high-density area dorsally on the left side, suggesting a hemothorax. When dorsal rib fractures are present, causes other than resuscitation efforts should be considered.