CQ37 Are postmortem images useful for identifying cervical spine injury/cervical cord injury?

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

Postmortem CT findings of cervical spine injuries include the following: cervical spine fracture, dislocation, edema and hematoma of the tissue surrounding the cervical spine, and pericardial subarachnoid hemorrhages (pseudo-CT myelogram signs). Postmortem MRI has been reported to be able to identify cervical spinal cord, intervertebral disc, and ligament injuries in addition to those listed above. Postmortem CT can point to damage that is missed by an autopsy, and its use as an adjunct to an autopsy is recommended. However, since there are cervical spine injury/cervical spinal cord injuries that are not verifiable by postmortem CT, it cannot be the basis for determining the cause of death, especially for negative proof of cervical spine injury/cervical spinal cord injury as a cause of death.

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

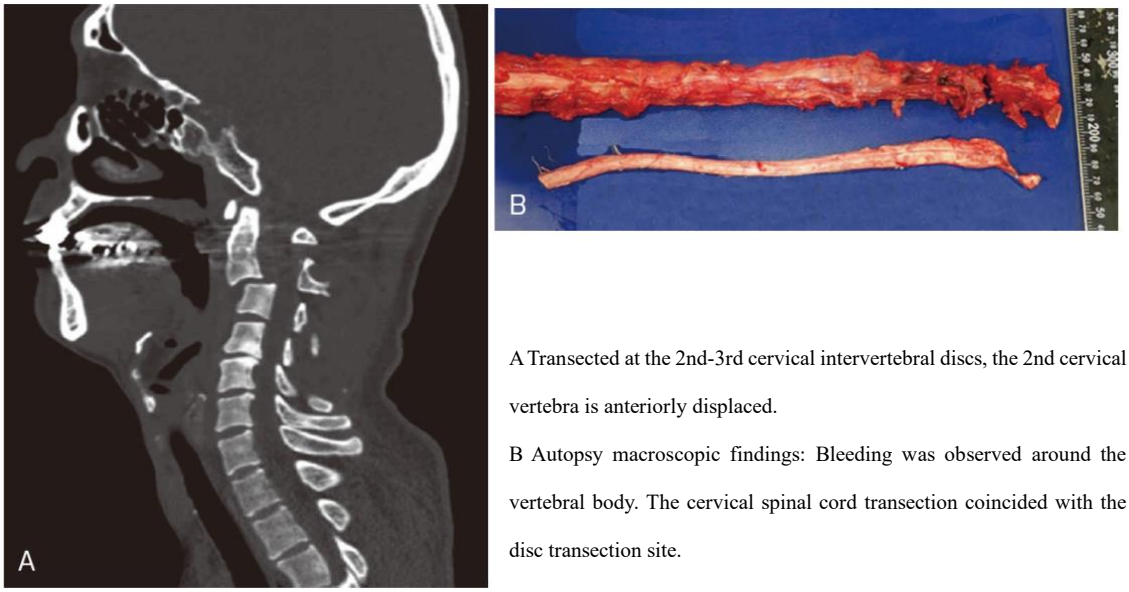
Cervical spine injuries are fractures, dislocations, intervertebral disc injuries, and similar occurring in the cervical spine due to direct or indirect external forces acting on the neck. It is often caused by hyperextension, hyperflexing, rotation, or compression of the neck during a traffic accident or due to falls from heights. Injuries are more common in the upper cervical spine (C1-2) and lower cervical spine (C5-7), often with cervical spinal cord injuries. Although cervical cord injuries above the 4th cervical cord are generally considered to be fatal [1, 2], injuries below the 4rth may also result in death related to neurogenic shock, quadriplegia with surrounding environmental factors (such as immobility in cold climates causing hypothermic death), or background weakness of the injured person (low excess ability due to sickness, or age) [3]. As it is difficult to identify cervical spine injuries from the external findings alone, a diagnosis with postmortem images is considered important.

Basic diagnostic image signs of cervical spine injury

Cervical spine injuries were once evaluated by plain radiography, but recent advances in CT have made it possible to reconstruct images in a sagittal section with little image deterioration, making CT the highest priority for determinations of such injuries in clinical settings [4]. With CT, it is desirable to record images with the thinnest possible collimation (width per detector row), and evaluations with multiplanar reconstruction including sagittal sections is the basic principal requirement (CQ14). Findings with MRI are useful because they allow visualization of lesions such as those of the cervical spinal cord, intervertebral discs, and ligaments, but it is not used for screening cervical spine injuries

from considerations of cost effectiveness. There are, however, some cervical spinal cord injuries that cannot be identified by plain radiography or CT, these are termed spinal cord injuries without radiographic abnormalities (SCIWORA) [5].

Figure 1 Male in the 50s, found under fallen objects at a construction site, with cervical intervertebral disc transection, and cervical spinal transection, (2 days after death)



A Transected at the 2nd-3rd cervical intervertebral discs, the 2nd cervical vertebra is anteriorly displaced.

B Autopsy macroscopic findings: Bleeding was observed around the vertebral body. The cervical spinal cord transection coincided with the disc transection site.

Cervical spine injury in postmortem images

Postmortem CT findings of cervical spine injuries include cervical fracture, dislocation, pericervical edema/hematomas, and pericervical subarachnoid hemorrhages (pseudo-CT myelogram signs) [3, 6-13]. The postmortem CT of a cadaver, which is presumed to have had an external force applied to the head and neck, improves the possibility of detecting cervical spine injuries by evaluating osteophyte formation and ossification of the anterior longitudinal ligament. For this reason, an evaluation of background factors is also recommended [11]. Postmortem CT are the most attractive modality for an autopsy in pointing out fractures. It is however inferior with intervertebral injuries such as intervertebral disc injuries and facet joint injuries (injuries that may be indicated as dislocations in images) [13]. Postmortem CT are able to identify cervical spine injuries that are missed by autopsies and postmortem CT obtained prior to an autopsy are considered highly useful. However, some injuries may be overlooked, and caution should be exercised in assessing the cause of death using postmortem CT alone. In particular, cervical spinal cord injuries (SCIWORA in postmortem CT), for which no findings with postmortem CT have been reported [3], as a result postmortem CT alone cannot determine that the cause of death is not cervical spinal cord injury/cervical spine injury.

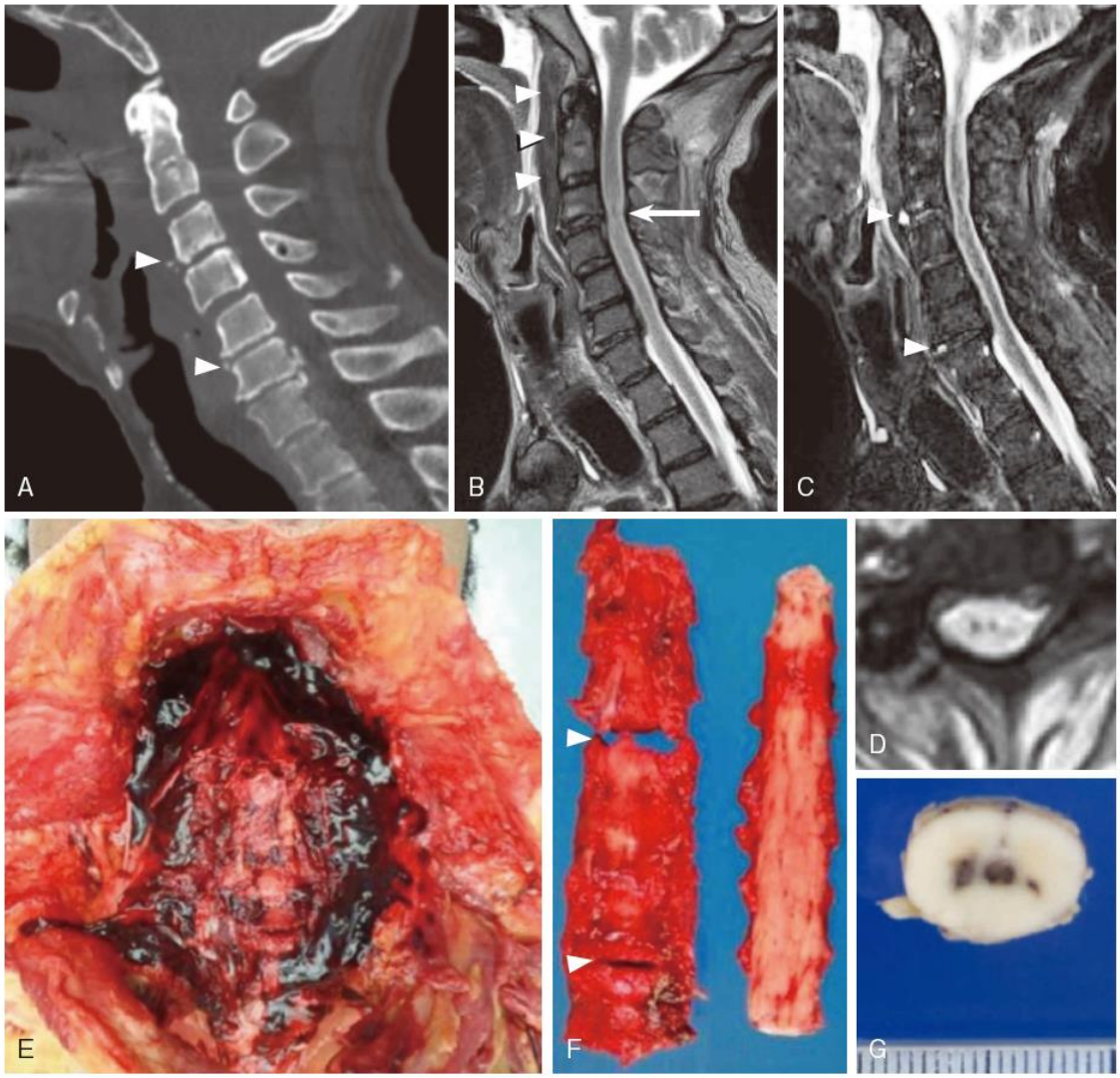
In addition, as a problem peculiar to postmortem images, it is difficult to distinguish whether an

injury is caused antemortem or postmortem when postmortem CT show fractures of the cervical spine but the hematomas in the surrounding tissue (or vital reaction) is not clearly depicted [7]. This is also one of the reasons why evaluation of the cause of death by postmortem CT alone is not recommended.

Other postmortem CT problems have been pointed out, these include postmortem rigidity, which makes it impossible to ensure proper neck positioning and excessively has a strong influence on determining atlanto-axial rotatory subluxation [10]. It has been reported that some sagittal reconstructed images, which are indispensable for assessing cervical spine injuries, are missing, or that the cervical spine itself is not included in the images [14]. It is necessary to have a standard protocol for postmortem CT optimized for cervical spine evaluation.

Postmortem MRI have been reported to make it possible to identify cervical spinal cord, intervertebral disc, and ligament injuries in addition to the findings pointed out by postmortem CT [6, 9]. If postmortem MRI is available, adding this is recommended. However, it should be noted that detailed examinations such as related to cost-effectiveness and presence/absence of false positives have not yet been made.

Figure 2, Cervical spine / spinal cord injury, discovered in the state after falling down the stairs from the 2nd floor to the 1st floor. A wound from the impact with the floor was observed in the forehead.



A Postmortem CT (sag): Small bone fragments are observed on the ventral side of C3-4 and C5-6 (arrowheads), but injuries to the intervertebral disc or cervical spinal cord are not clearly observed.

B Postmortem MR (T2wi, sag): Vertebral ventral hematoma (arrowhead) and C3-4 cervical spinal cord injury (at →).

C Postmortem MR (fat suppression T2wi, sag): A high signal intensity (arrowhead) similar to that of cerebrospinal fluid [was found] is located at the anterior margins of the C3-4 and C6-7 intervertebral discs, suggesting disc damage.

D Postmortem MR (T2*, axi): A punctate hypointensity was found in C3-4 of the cervical cord, and bleeding was considered.

E Autopsy macroscopic findings: A hematoma is found in front of the cervical vertebra after the autopsy of the cervical trachea.

F Autopsy macroscopic findings: Disc incision (arrowhead) is observed at C3-4 and C6-7.

G Macular bleeding was observed in the gray matter of C3-4 central cervical spinal cord in the transverse section after cervical spinal cord fixation.

Literature search formula and literature selection (2019/5/27)

PubMed

#	Search formula	Number of documents
1	((((((((((postmortem)OR post-mortem)OR "post mortem"))AND imaging))OR(((((postmortem)OR post-mortem)OR "post mortem")) AND CT))OR(((((postmortem)OR post-mortem)OR "post mortem")) AND "computed tomography"))OR(((((postmortem)OR post-mortem) OR "post mortem"))AND MR))OR(((((postmortem)OR post-mortem) OR "post mortem"))AND "magnetic resonance")))OR(((((postmortem) OR post-mortem)OR "post mortem"))AND MDCT))OR((MSCT) AND(((postmortem)OR post-mortem)OR "post mortem"))	23,638
2	“cervical fracture”	397
3	“cervical spine”	21,186
4	“spinal cord injury”	33,618
5	“spinal cord injuries”	37,468
6	(((#2)or #3)or #4)or #5	67,695
7	#1 and #6	207

Ichushi（Medical Journal）

#	Search formula	Number of documents
1	(死後/AL)and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	4,582
2	(死亡時/AL)and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	683
3	((画像診断/TH or 画像診断/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	270,065
4	((X 線 CT/TH or X 線 CT/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	103,856
5	((MRI/TH or MRI/AL))and((FT=Y)PT= 原著論文, 会議録除く CK= ヒト)	86,742
6	#1 or #2	5,058
7	#3 or #4 or #5	280,349
8	#6 and #7	1,228
9	((頸椎損傷/TH or 頸椎損傷/AL))and((FT=Y)PT= 会議録除く CK= ヒト)	167
10	#8 and #9	4

From other than search formula

[1, 2, 4]

References

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[5] Kasimatis GB et al: The adult spinal cord injury without radiographic abnormalities syndrome: magnetic resonance imaging and clinical findings in adults with spinal cord injuries having normal radiographs and computed tomography studies. J Trauma 2008; 65: 86-93 (Level 4b)

[6] Yen K et al: Postmortem multislice computed tomography and magnetic resonance imaging of odontoid fractures, atlantoaxial distractions and ascending medullary edema. Int J Legal Med 2005; 119: 129-136 (Level 5)

[7] Iwase H et al: Can cervical spine injury be correctly diagnosed by postmortem computed tomography? Leg Med 2009; 11: 168-174 (Level 5)

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[10] Persson A et al：Atlanto-axial rotatory subluxations in postmortem CT：radiologists be aware of a common pitfall. Forensic Sci Int 2013；225：9-14（Level 4b）

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[13] Makino Y et al：Differences between postmortem CT and autopsy in death investigation of cervical spine injuries. Forensic Sci Int 2017；281：44-51（Level 4b）

[14] Kanamaru A et al: Investigation of Cause of Death due to Trauma Using Autopsy Imaging： Possibility of Death due to Spinal Cord Injury. Chugoku-Shikoku Seikeigeka Gakkaishi 2013 ;

25 : 283-288 (Level 4b) (Japanese)