CQ28: Is it possible to identify fatal subarachnoid hemorrhage on postmortem CT?

Recommendation Grade:

Condition Assessment: B

Cause of Death Determination: C1

As with antemortem CT, postmortem CT can identify subarachnoid hemorrhage (SAH). When large amounts of subarachnoid blood are observed in the basal cisterns or when SAH is accompanied by intraventricular hemorrhage, SAH may be considered as a potential cause of death. However, postmortem changes and other non-hemorrhagic conditions can mimic bleeding, and care must be taken to distinguish true SAH from such artifacts during image interpretation. There are currently no reports indicating that postmortem CT findings alone can determine whether SAH is of internal (natural) or external (traumatic) origin. Accurate diagnosis requires the implementation of appropriate additional examinations.

Explanation

● Background

Subarachnoid hemorrhage (SAH) is a life-threatening condition with high mortality, and it has been reported that 3–17% of cases result in death before reaching the hospital[1]. CT imaging is essential in clinical practice for determining the treatment strategy for SAH. Similarly, postmortem CT can detect abnormalities and is considered capable of identifying the presence of hemorrhage in the subarachnoid space. However, postmortem CT does not always allow for determination of the underlying cause, and there is a risk of misdiagnosis[2], which requires caution during image interpretation. It is often difficult to determine whether the cause is of external (traumatic) or internal (natural) origin using postmortem imaging alone, and the implementation of supplementary examinations is considered essential[3]. As with antemortem CT, pseudo-subarachnoid hemorrhage (pseudo-SAH) has also been reported as a false-positive finding in postmortem CT[4]. Research applying artificial intelligence (AI) in the diagnosis of fatal head trauma has already begun[5], and further advancements and utilization are anticipated.

● Imaging Findings

1) Correlation Between Postmortem CT and Autopsy Findings in Subarachnoid Hemorrhage

Several studies have reported that subarachnoid hemorrhage (SAH) detected on postmortem CT has been confirmed during autopsy[167]. In an analysis of 203 cases in which both autopsy and postmortem CT were performed, there was a high concordance rate between CT and autopsy findings for SAH, whereas subdural and epidural hematomas showed relatively lower concordance rates[8]. In addition, a method has been reported in which contrast medium is injected into the common carotid or vertebral

artery using a catheter during autopsy, allowing for CT imaging that identifies the site of vascular rupture before cranial opening[9].

2) Pseudo-Subarachnoid Hemorrhage (Pseudo-SAH)

On antemortem CT, in conditions such as hypoxic-ischemic encephalopathy, diffuse low-density cerebral edema and swelling may cause the cerebral sulci and basal cisterns to appear relatively hyperdense. This phenomenon is known as pseudo-subarachnoid hemorrhage (pseudo-SAH) (see also CQ27)[10–12].

3) Traumatic vs. Non-traumatic Subarachnoid Hemorrhage

A systematic review examining the relationship between pre-existing aneurysms and trauma reported that although rare, arteries and aneurysms can rupture in association with trauma[13]. Among traumatic SAH cases, delayed vertebral artery injury has been reported[3 14 15]. Non-traumatic conditions such as arteriovenous malformations[16] and segmented arterial mediolysis[17] have also been reported as causes of SAH. Determining whether the cause is traumatic or non-traumatic may require additional testing, such as histopathological or molecular analysis[3].

There are also reports indicating that the source of hemorrhage cannot always be identified at autopsy[13]. The injection of contrast agents to identify the ruptured vessel may assist in such cases and support histopathological or molecular investigations[10].

Column: Posterior Cranial Fossa to Upper Spinal Canal (True vs. Pseudo Hematoma)

In postmortem CT, the region from the posterior cranial fossa to the upper cervical spinal canal is typically included in the scanning field. This area can sometimes be inadequately examined during autopsy, and thus requires careful observation. When high attenuation is noted around the posterior cranial fossa or upper cervical spinal cord, it is important not to overlook potentially fatal subdural hematomas[18–21]. However, attention should also be paid to pseudo-hematomas. Because of venous congestion caused by the network between the cranial venous system and the vertebral venous plexus, one report noted that no hematoma was confirmed in 13 out of 35 cases (37%)[22].

○ Literature Search Strategy and Selection

【PubMed】（2024/6/19）

#	Search formula	Number of articles
1	Search:(((postmortem) OR (post-mortem)) OR (post mortem)) AND ((CT) OR (MDCT) OR (MRI))	13,768
2	Search:(subarachnoid) AND (hemorrhage)	41,808

3	Search:(#1) AND (#2)	263

【医中誌 Ichushi-Web (Japan Medical Abstracts Society Database)】（2024/6/1）

#	Search formula	Number of articles
1	((死亡時画像診断/TH or 死後画像/AL)or(死亡時画像診断/TH or オートプシーイメージング/AL)or((@X 線 CT/TH and @死亡時画像診断/TH)or 死後 CT/AL))and(PT=原著論文,解説,総説,図説, Q&A,講義,会議録除く)	825
2	#1 and(クモ膜下出血/TH or くも膜下出血/AL)	24

■References

1) Schievink WI et al：Sudden death from aneurysmal subarachnoid hemorrhage. Neurology 1995；45：871-874（level 5）

2) Serinelli S et al：Head and brain postmortem computed tomography-autopsy correlation in hospital deaths. Am J Forensic Med Pathol 2020；41：163-175（level 4b）

3) Smyk DS, Herath JC：Delayed rupture of a vertebral artery laceration：a case report and challenges for the forensic pathologist. Forensic Sci Med Pathol 2018；14：536-540（level 5）

4) Shirota G et al：The pseudo-SAH sign：an imaging pitfall in postmortem computed tomography. Int J Legal Med 2017；131：1647-1653（level 4b）

5) Garland J et al：Identifying fatal head injuries on postmortem computed tomography using convolutional neural network/deep learning：a feasibility study. J Forensic Sci 2020；65：2019-2022（level 4b）

6) Sheikhazadi A, Gharehdaghi J：Survey of sudden death from aneurysmal subarachnoid hemorrhage in cadavers referred to Legal Medicine Organization of Tehran, 2001-2005. Am J Forensic Med Pathol 2009；30：358-361（level 5）

7) Huang J, van Gelder JM：The probability of sudden death from rupture of intracranial aneurysms：a meta-analysis. Neurosurgery 2002；51：1101-1105；discussion 1105-1107（level 1）

8) Graziani G et al：Usefulness of unenhanced post mortem computed tomography - Findings in postmortem non-contrast computed tomography of the head, neck and spine compared to traditional medicolegal autopsy. J Forensic Leg Med 2018；55：105-111（level 4b）

9) Inokuchi G et al：Postmortem dynamic cerebral angiography for detecting aneurysm and bleeding sites in cases of subarachnoid hemorrhage. Forensic Sci Med Pathol 2014；10：487-495（level 4b）

10) Fretwell ME et al：Pseudo subarachnoid hemorrhage sign in bacterial meningitis in a patient presenting with acute ischemic stroke：a novel radiological clue to rapid diagnosis. Cureus 2022；

14：e25283（level 5）
11) Platt A et al：Pseudosubarachnoid hemorrhage：a systematic review of causes, diagnostic modalities, and outcomes in patients who present with pseudosubarachnoid hemorrhage. Surg Neurol Int 2021；12：29（level 1）
12) Zubair AS et al：Pseudosubarachnoid hemorrhage. Surg Neurol Int 2022；13：32（level 5）
13）Steinmann J et al：Rupture of intracranial aneurysms in patients with blunt head trauma：Review of the literature. Clin Neurol Neurosurg 2020；199：106208（level 1）
14) Kawauchi M et al：A vertebral artery aneurysm that elicited occipital pain, showed no abnormalities on imaging studies, but ruptured the next day：illustrative case. J Neurosurg Case Lessons 2024；7：CASE23723（level 5）
15) Wang T et al：Massive brainstem and cerebellum infarction due to traumatic extracranial vertebral artery dissection in a motor traffic accident：an autopsy case report. Am J Forensic Med Pathol 2021；42：194-197（level 5）
16）Oomori M et al：Fatal ruptured occult arteriovenous malformation in a young adult：an autopsy case report. Surg Neurol Int 2022；13：284（level 5）
17) Nakano F et al：A case presenting as fatal subarachnoid hemorrhage due to segmental arterial mediolysis associated with Crohn's disease. Cardiovasc Pathol 2021；54：107363（level 5）
18）Wen S et al：Importance of repeated computed tomography on pediatric traumatic acute posterior fossa subdural hematoma：a case study. Leg Med 2024；70：102466
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21）Menezes AH et al：Posterior fossa hemorrhage in the term neonate. Neurosurgery 1983；13：452-456
22）Kuninaka H et al：Distinguishing true from pseudo hematoma in the cervical spinal canal using postmortem computed tomography. Leg Med 2024；66：102358

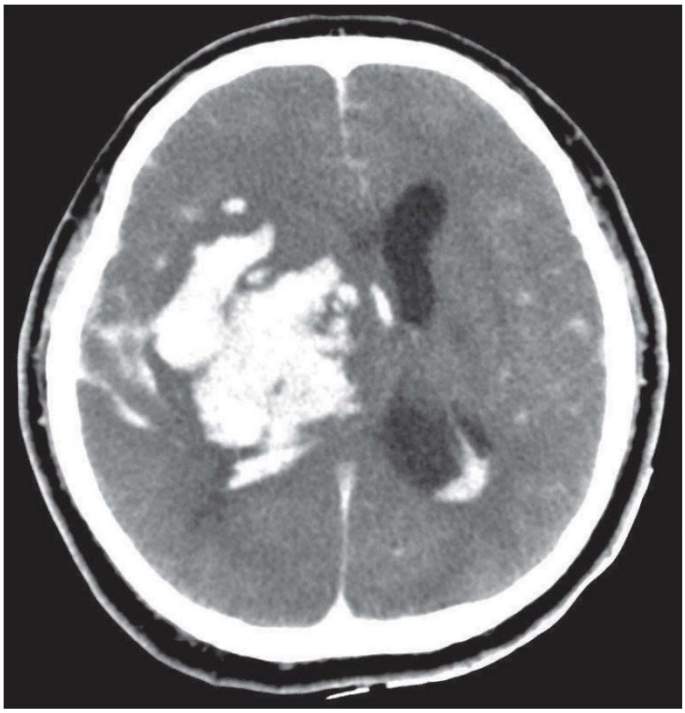

Figure 1. Male in his 50s – Intracerebral and Subarachnoid Hemorrhage

Hemorrhage is observed in the right basal ganglia, with accompanying intraventricular and subarachnoid hemorrhage. A mild brain herniation to the left side is also noted.

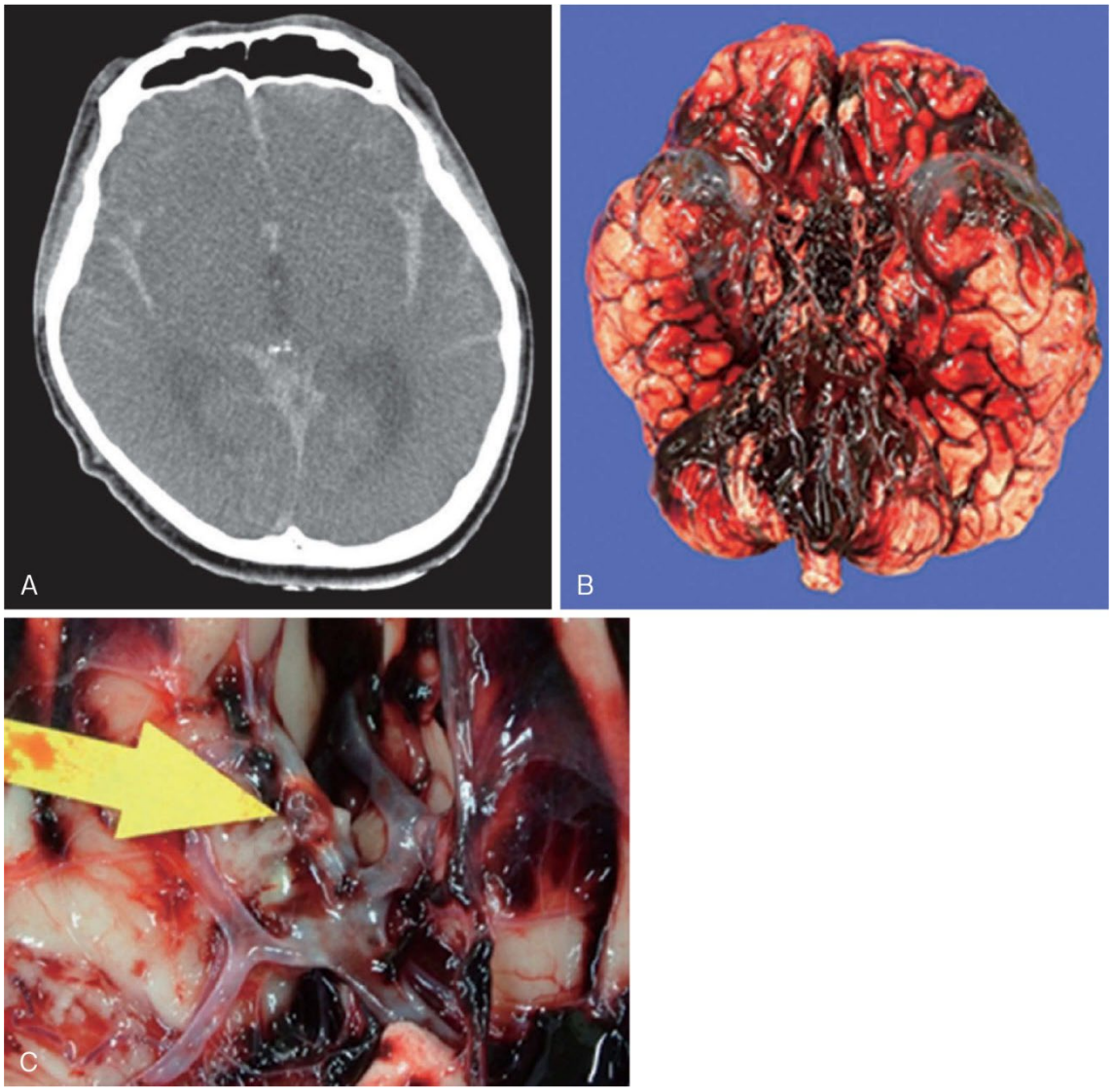

Figure 2. Male in his 50s – Autopsy Case of Ruptured Cerebral Aneurysm Found in Bathtub at Home (Postmortem Day 3)

A. CT: High-density areas are observed in the subarachnoid space, indicating subarachnoid hemorrhage.

B. Autopsy (macroscopic findings): A dense hematoma is noted at the base of the brain.

C. Autopsy (macroscopic findings): After removal of the hematoma at the brain base, a ruptured aneurysm is identified in the anterior cerebral artery.

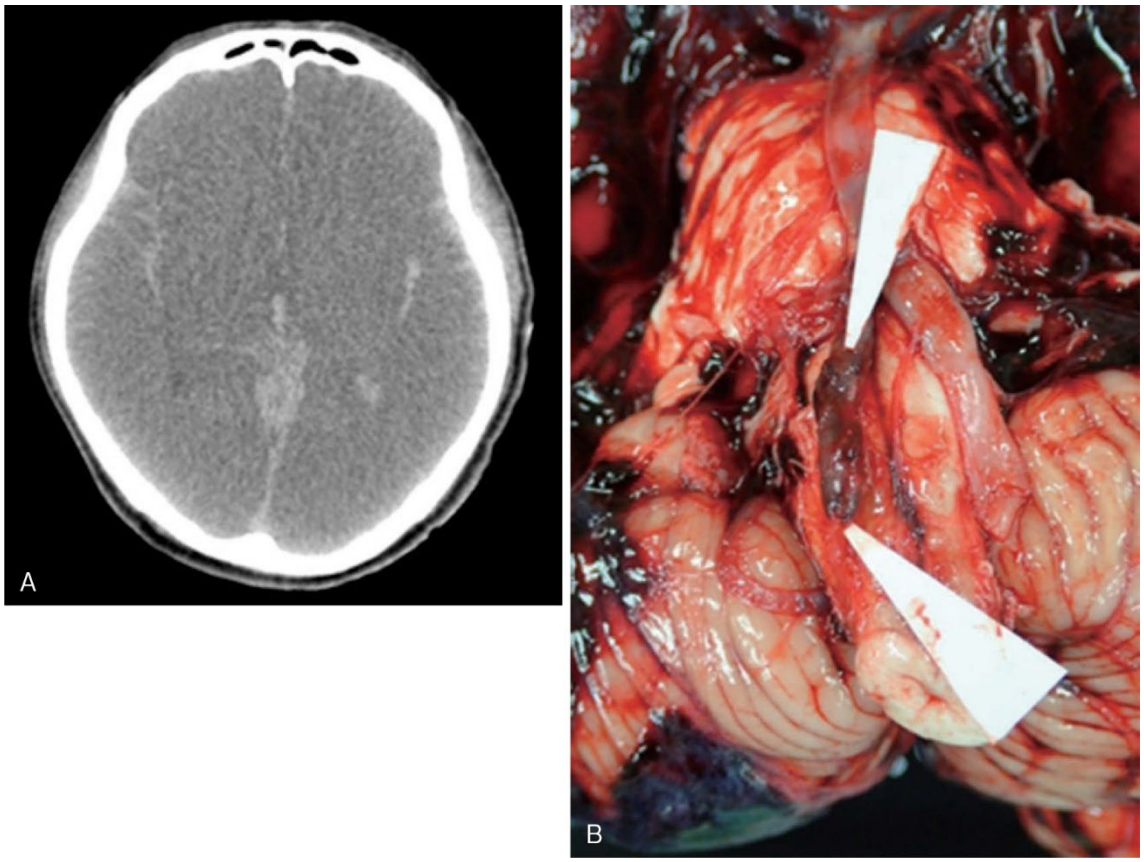

Figure 3. Male in his 60s – Autopsy Case of Subarachnoid Hemorrhage Due to Vertebral Artery Dissection (Collapsed Suddenly in Front of Family, Postmortem Day 2)

A. CT: Subarachnoid hemorrhage appears as high-density areas, identical to clinical imaging findings. No apparent trauma was observed in the head or neck during autopsy.

B. Autopsy (macroscopic findings): An isolated rupture from arterial dissection is identified in the right vertebral artery.

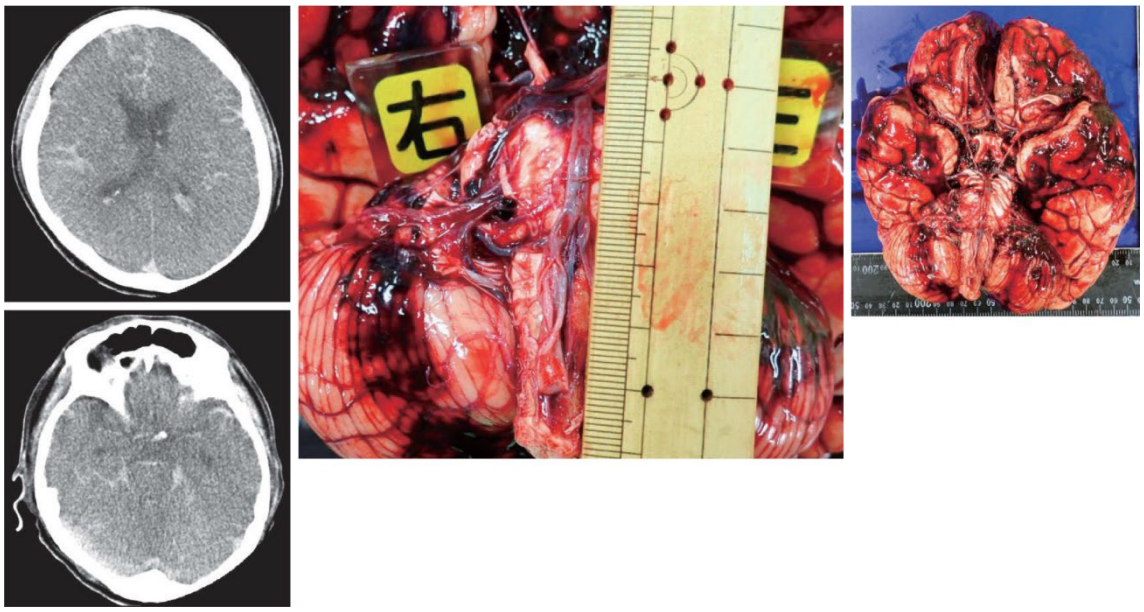

Figure 4. Male in his 40s – Traumatic Subarachnoid Hemorrhage

While driving alone, the individual fell from a cliff. At the receiving hospital, spontaneous subarachnoid hemorrhage was initially suspected as the cause of the accident. Autopsy revealed right vertebral artery injury and cervical spinal cord damage (not shown).

High blood alcohol concentration was detected.

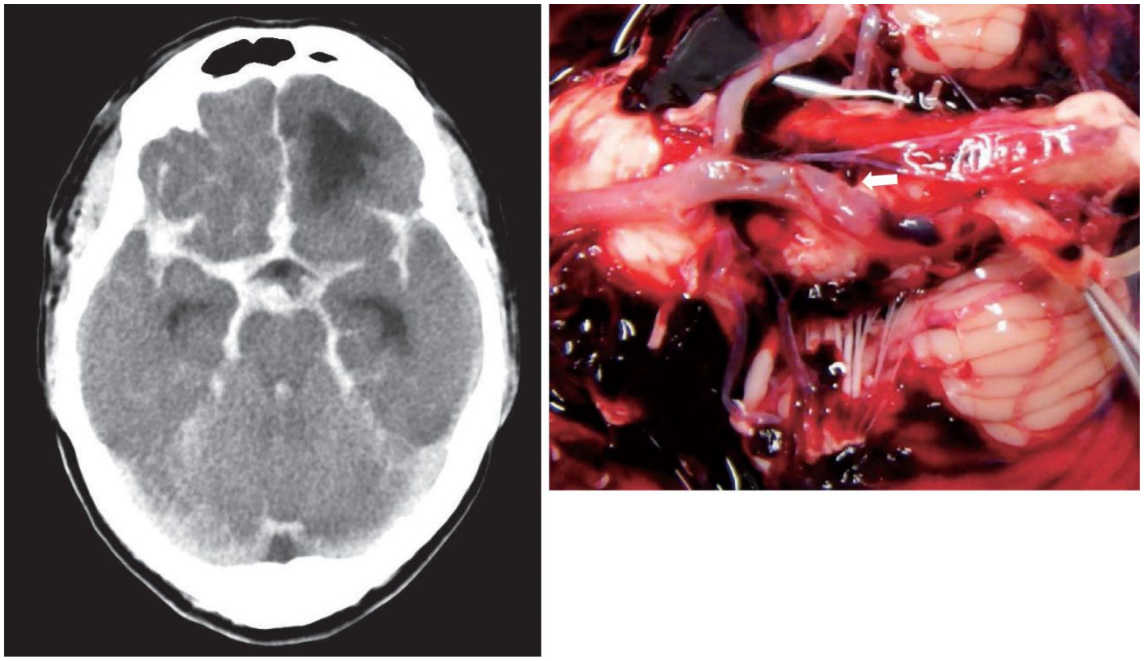

Figure 5. Male in his 40s – Vertebral Artery Dissection

Subarachnoid hemorrhage is observed along with an old infarction in the left frontal lobe.

Autopsy revealed a dissection in the right vertebral artery. When fluid was injected into the vessel, leakage was observed from the rupture site (⇦). Toxicological testing was positive for methamphetamine, raising traumatic subarachnoid hemorrhage (SAH) as a differential diagnosis.