Cerebrospinal fluid-venous fistula detected in a patient with a long history of headaches

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History

A 58-year-old female patient with a 10-year history of migraine, tinnitus and orthostatic headache, was referred to the department of neuroradiology for evaluation. Symptoms were typical for spontaneous intracranial hypotension (SIH) and a brain MRI with i.v. contrast material confirmed the diagnosis, demonstrating dural enhancement, venous distension, and brain sagging. A prior attempt at finding the causative spinal cerebrospinal fluid-venous fistula (CVF) three years earlier was unsuccessful. CT myelography (CTM) was performed on a dual source photon-counting CT (PCCT), NAEOTOM Alpha®, using an ultra-high resolution (UHR) scan mode (Quantum HD) to identify and localize the CVF prior to a definitive treatment.

Diagnosis

Previous CTM images, acquired at 0.625 mm slice thickness on an energy-integrating-detector (EID) CT, had revealed prominent spinal nerve root sleeves at multiple levels, however, was unable to identify the CVF (Fig. 1a). For this new exam, UHR CTM images were acquired at 0.2 mm slice thickness on PCCT in left lateral and right lateral decubitus, and prone position at rest, end-inspiration breath hold, and during Valsalva maneuver, after the injection of 10 mL of iopamidol (300 mg/mL) into the subarachnoid space via lumbar puncture. The UHR images in end-inspiration revealed the causative sub-millimeter CVF arising from the right T5 level, evidenced by contrast in an adjacent paraspinal vein (Fig. 1b). Additional clarity was gained from the iodine map (Fig. 1c) as well as the 3D images created by cinematic volume rendering technique (cVRT, Fig. 1d). Identification and localization of this CVF allowed the patient to be referred to neurosurgery for definitive treatment with surgical ligation. Surgery was successful resulting in resolution of her symptoms and normalization of brain MRI findings of SIH.

Comments

CVFs represent abnormal connections between the spinal subarachnoid space and adjacent paraspinal veins. These anomalous connections allow for uncontrolled outflow of cerebrospinal fluid (CSF) into the venous system, ultimately leading to intracranial hypotension. Although CVFs have been recognized only recently, they have rapidly emerged as a common underlying cause of spinal CSF leaks in patients with SIH, particularly in cases where initial spinal imaging fails to reveal any obvious leaks.

CVFs are most frequently found in the thoracic spine, particularly in the lower levels from T7 to T12. However, they can also occur in upper thoracic levels, as presented in this case. Fistulas in the upper lumbar or lower cervical levels are less common. CVFs are anatomically associated with a nerve root sleeve, with the fistulous connection frequently originating from the nerve root sleeve itself, as seen in this case. While some case series have suggested a possible laterality preference, the evidence for such a predilection is not strong, and CVFs can occur on either side of the spine.

Unlike dural tears, which were the first described cause of intracranial hypotension, most CVFs do not lead to the pooling of CSF in the epidural space. This lack of epidural fluid accumulation makes it challenging to detect CVFs through conventional anatomical imaging. Instead, the use of a myelographic contrast agent specific to CSF is necessary for their visualization. Consequently, standard spine MRI, commonly employed for detecting epidural CSF leaks, is not effective for identifying CVFs and CTM has emerged as a better imaging modality. The traditional challenge with EID CT scanners is to improve the spatial resolution without increasing radiation dose or accepting excessive image noise. This has become possible with the introduction of PCCT. It is feasible to acquire UHR images at full dose efficiency without the application of additional hardware like combs or grids to reduce the detector aperture at the cost of reduced dose efficiency as this would be the case with EID CT. As shown in this case, the CVF was not visible on the previous scan conducted on an EID CT with the traditional thin-slice approach; but it was successfully identified now on the PCCT with its inherent UHR mode

at 79% of radiation dose reduction (8.6 mGy with PCCT vs. 41.3 mGy with EID CT). A model-based iterative reconstruction approach – Quantum Iterative Reconstruction (QIR) – is applied in the image reconstruction process for further image noise reduction. It is worth noting that the combination of UHR images and spectral information (albeit at somewhat reduced resolution) is unique for PCCT, providing UHR morphological images and the spectral images with chemical composition information (iodine map) from the same data. In this case, the iodine maps generated from the spectral information gave additional confidence in visualizing the CVF identified in the UHR images. The improved visualization helps the physicians make a confident diagnosis and facilitates an appropriate treatment planning. The patient was relieved from a long history of headaches.
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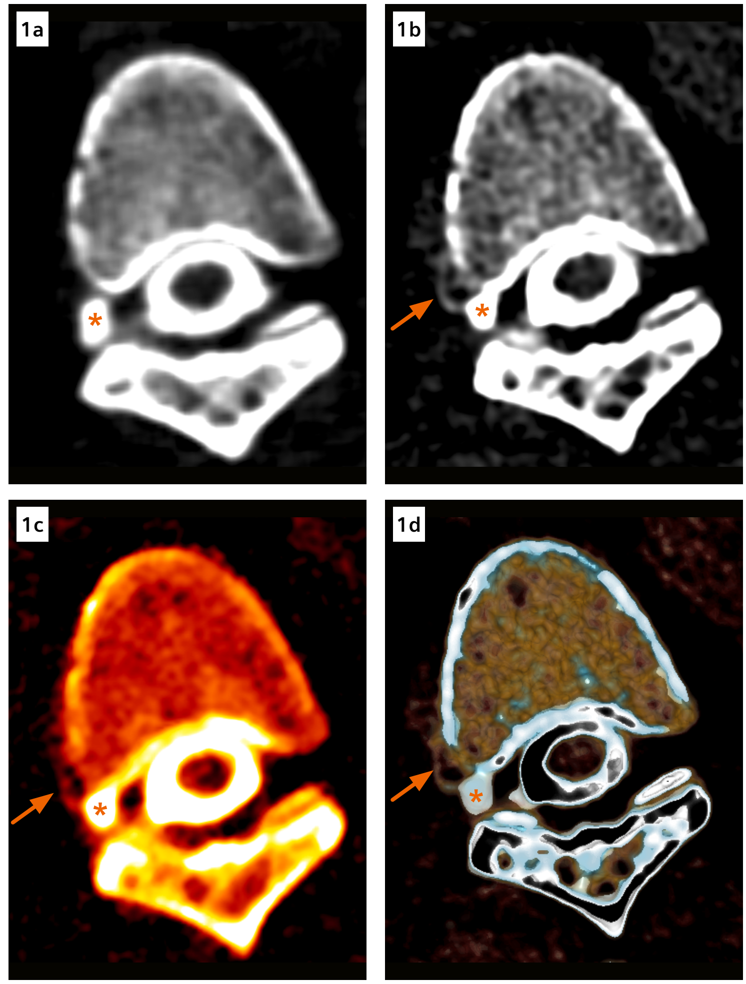
Examination Protocol

Scanner	NAEOTOM Alpha
Scan area	Spine
Scan mode	UHR (Quantum HD)
Scan length	354 mm
Scan direction	Caudo-Cranial
Patient position	FFDR (Feet First Decubitus Right)
Scan time	7.6 s
Tube voltage	140 kV
Tube current	74 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	8.58 mGy
DLP	341 mGy cm
Rotation time	0.5 s
Pitch	0.85
Slice collimation	120 x 0.2 mm
Slice width	0.2 mm
Reconstruction increment	0.2 mm
Reconstruction kernel	Br48u, QIR 4

Contrast	iopamidol (300 mg/mL)
Volume	10 mL
Flow rate	Manual injection



1 **An axial image, acquired at 0.625 mm on an EID CT at the level of T5 (Fig, 1a), shows a prominent nerve root sleeve visible to the right of the spinal canal (asterisk). A CVF is not apparent. A UHR image, acquired at 0.2 mm on PCCT (Fig. 1b) shows a prominent nerve root sleeve (asterisk) and a visible CVF at the same level (arrow). An iodine map (Fig. 1c, 0.4 mm) and a thin slab cVRT image (Fig. 1d) show the CVF (arrows) at the same location.**