

Diagnostic Value of The Cortical Vein Sign: Unreliable Index of Atrophy on MR Image

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Objective: Differentiation of the subdural and the subarachnoid spaces is a matter of debate in the extracerebral fluid collections. Visualization of the cortical veins, so-called cortical vein sign was proposed as an index of the subarachnoid space. We examined the validity of this sign.

Methods: We reviewed the anatomy of cerebral meninges in the literature. We also examined the cortical vein sign in some patients with extracerebral fluid collections, evaluated by magnetic resonance imaging and computed tomography.

Results: The subarachnoid space is a space below the arachnoid barrier cell layer, above the pia mater, and between arachnoid trabeculae. Since the trabeculae are not elastic, the subarachnoid space cannot be enlarged unless the trabeculae are torn. Before tearing of the trabeculae, dural border cell layer of the dura will be separated. Anatomically, the subarachnoid space cannot expand beyond the limit of the trabeculae. The cortical veins lie on the surface of intima pia anchored by arachnoid trabeculae. As they approach the convexity, cortical veins cross the arachnoid and dura, draining into the sinus. Near the sinuses, these vessels lie between the dura and the arachnoid, and they can be seen even in patients with subdural hygroma.

Conclusion: The cortical vein sign is not useful to differentiate subdural hygroma and atrophy.

Key Words: Magnetic resonance imaging · Subdural hygroma · Atrophy · Subarachnoid space · Diagnosis



INTRODUCTION

Extracerebral or pericerebral fluid collection includes subdural hygroma^{7,25,26)}, subdural effusion^{10,12,18)}, enlargement of the subarachnoid spaces (SAS) or wide SAS^{11,20)}, and external hydrocephalus^{1,13,15,16,24)}. Some diagnostic terms are vague and there are some overlapping syndromes. In any events, the key element of the differentiation is whether the collection is in the subdural space or in the SAS. It is not easy to distinguish these two spaces even by the magnetic resonance (MR) imaging. Visualization of the cortical veins or vascular flow-void areas in the fluid spaces was proposed as an index of SAS, and named as 'the cortical vein sign'¹⁷⁾. Some authors^{2,7,13)} used this sign to differentiate the subdural space and the SAS.

However, we observed the cortical vein signs in some patients with subdural hygroma, and questioned the reliability of this sign. We examined the diagnostic value of the cortical vein sign.



MATERIALS AND METHODS

We reviewed the anatomy of cerebral meninges in the literature. We also examined the cortical vein sign in some patients with extracerebral fluid collections, evaluated by MR imaging and computed tomography.



RESULTS

1. Widening of the subarachnoid space is possible?

Cerebral meninges consist of the pia mater, arachnoid mater, and dura mater^{5,9)}. Dura mater consists of three layers, periosteal dura, meningeal dura, and dural border cell (DBC) layer. Morpho-

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logically, DBC layer has few cell junctions, no extracellular collagen, and enlarged extracellular spaces, being a structurally weak layer between the dura-arachnoid interface. Arachnoid mater consists of arachnoid barrier cells and arachnoid trabeculae⁹⁾, and SAS is a space below the arachnoid barrier cell layer, above the pia mater, and between arachnoid trabeculae. Fibroblasts forming the arachnoid trabeculae have long, flattened, irregular processes that are attached to each other by cell junctions and reinforced by collagen⁹⁾. When there is a force to separate the cerebral meninges, the DBC layer of the dura will be separated. The arachnoid does not separate because it is essentially anchored by the trabeculae and their attachments to the pia⁹⁾. So, enlargement of the SAS cannot extend beyond the limit of the trabeculae.

2. Do the cortical veins located only in the subarachnoid space?

The superficial cerebral veins arise from the cortex and subcortical medullary substance, anastomose freely in the pia and form a number of large vessels, which empty into various sinuses. The superior cerebral veins open into the superior sagittal sinus or its venous lacunae⁶⁾. Cerebral vessels lie on the surface of intima pia anchored by arachnoid trabeculae. As they approach the convexity, cortical veins cross the arachnoid and dura, draining into the sinus²¹⁾. These cortical veins are usually well visualized in the T2 weighted image or Gadolinium enhanced image (Fig.

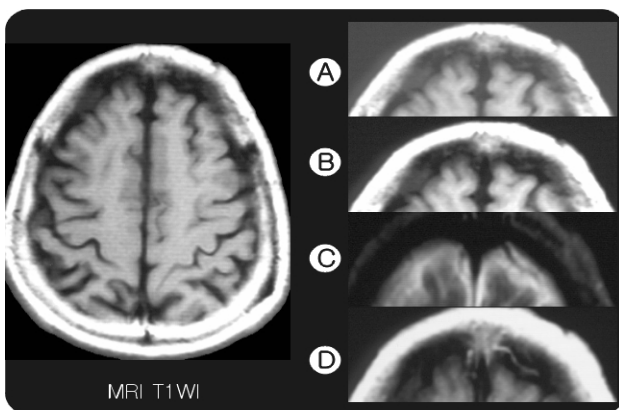


Fig. 1. The cortical veins are usually well visualized in the T2 weighted image (WI) or Gadolinium enhanced image. **A & B:** T1WI after adjustment of the brightness and contrast, **C:** T2WI, **D:** Gadolinium enhanced image.

1). Near the sinuses, these vessels lie between the dura and the arachnoid, and they can be seen even in patients with subdural hygroma (Fig. 2). Most of the superior cortical veins are 1 mm or less in diameter²¹⁾. These veins are usually invisible in the frontal region. Cortical vein sign is most common near the level of centrum semiovale, where these vessels are large enough to be seen (Fig. 3).



DISCUSSION

The SAS is a space between arachnoid trabeculae. Since the trabeculae are not elastic, the SAS cannot be enlarged unless the trabeculae are torn. Before tearing of the trabeculae, DBC layer will be separated. Anatomically, the SAS can only expand up to the given length of the trabeculae. Strictly speaking, there can

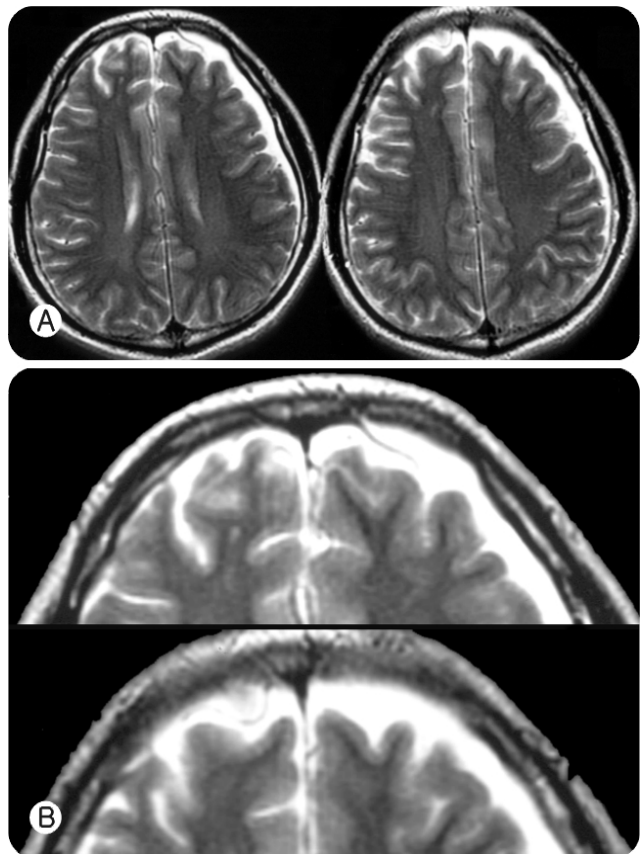


Fig. 2. Near the sagittal sinus, we can see the cortical veins in this 36-year old male patient with subdural hygroma after head injury (**A**). The cortical veins are clear in the enlarged view (**B**).

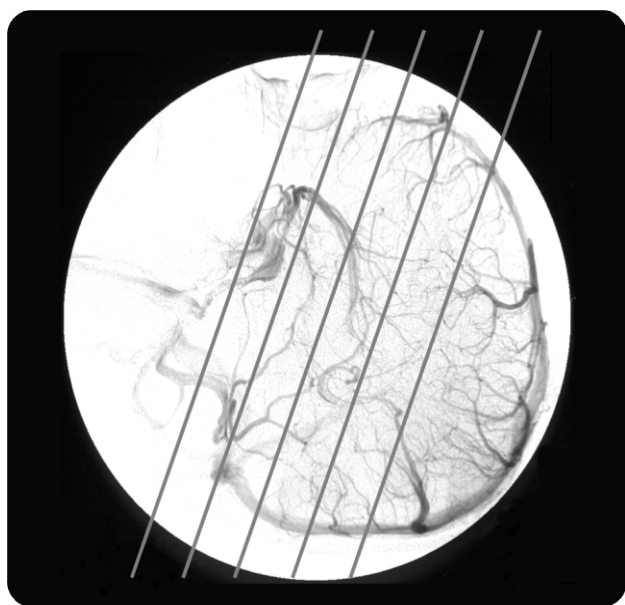


Fig. 3. Cortical vein sign is most common near the level of centrum semiovale, where the cortical veins are large enough to be seen.

be a restoration of the compressed or relaxed SAS or filling up the SAS with cerebrospinal fluid (CSF). Widening, dilatation or enlargement of the SAS cannot occur beyond the limit of the trabeculae. Even in patients with severe cortical atrophy, it is hard to find a case with wide SAS exceeding 10 mm from the pia.

Till 1990s, it has been hard to distinguish the subdural space and the SAS. There have been numerous diagnostic terms, such as subdural hygroma¹⁷⁾, subdural effusion^{10,12)}, subdural collections^{3,23)}, benign enlargement of the SAS²⁰⁾, subarachnoid fluid collection¹⁹⁾, enlarged CSF spaces¹¹⁾, and external hydrocephalus^{1,13,15,24)}. More collective terms such as extracerebral^{2,28)}, extraxial⁴⁾ or pericerebral^{7,8,27)} fluid collections are also used. Now, we can differentiate these spaces by the high resolution MR imaging. Delineation of these extracerebral collections can be possible.

A physiologic focal widening of the SAS is the arachnoid cistern. Focal pathologic widening is named as the arachnoid cyst. Congenital arachnoid cysts are common near the arachnoid cisterns. Intradiploic arachnoid cysts are within the diploe of the skull. Traumatic arachnoid cyst may cross the skull, and may lack the dural covering, but covered by the arachnoid membrane. Even though a CSF-filled cyst is below the skull, the cyst is named as a cystic subdural hygroma when the outer wall of the

cyst lacks the arachnoid covering²²⁾. Diffuse widening of the SAS within the limit of the trabeculae may be designated as an enlarged SAS. However, from collapse to full restoration, such changes in volume of the SAS are rather physiologic. If the brain shrinks beyond the physiologic limit, then the weakest layer of the cerebral meninges, the DBC layer, will be separated and a subdural hygroma will be developed¹⁰⁾.

Any fluid collections are not physiologic in the subdural space. Subdural hygroma is a subdural fluid collection usually after head injury, and those lesions after infections or inflammations are often called as subdural effusion. Mori et al¹⁸⁾ defined subdural hygroma as a subdural CSF collection communicating with the SAS, while subdural effusion as an encapsulated, non-communicating subdural fluid collection. When a subdural space is created, the barrier between the subdural space and SAS is the arachnoid barrier cell layer. This translucent layer has numerous tight junctions to serve as a barrier against the movement of fluid. However, there can be a small perforation or a tear of this layer, which may allow to drain CSF to the subdural cavity. At first, such a small opening remained to allow free drainage of the CSF. Later, it will be obliterated by the neomembrane. Any pathologic condition inducing cleavage of tissue within the dural border layer at dura-arachnoid interface can induce proliferation of dural border cells with production of neomembrane¹⁴⁾. When this neomembrane encapsulated the whole subdural cavity including the opening, the hygroma becomes the effusion.

The definition, etiology and pathophysiology of external hydrocephalus remain unclear^{16,18)}. If the term external hydrocephalus means a wide SAS with CSF accumulation, it might be a misnomer. The SAS is normally filled with CSF. In any events, further studies are necessary for the correct concept of external hydrocephalus.

Differentiation of the space, whether the subdural or the subarachnoid, is a matter of debate, besides the definitions of the various diagnostic terms designating extracerebral or pericerebral fluid collections. McCluney et al¹⁷⁾ proposed so-called cortical vein sign. However, the cortical veins lie between the dura and the arachnoid near the sinuses, and they can be seen even in patients with subdural hygroma. If there is a cortical vessel below the extracerebral collection, the lesion will be subdural hygroma (Fig. 4).

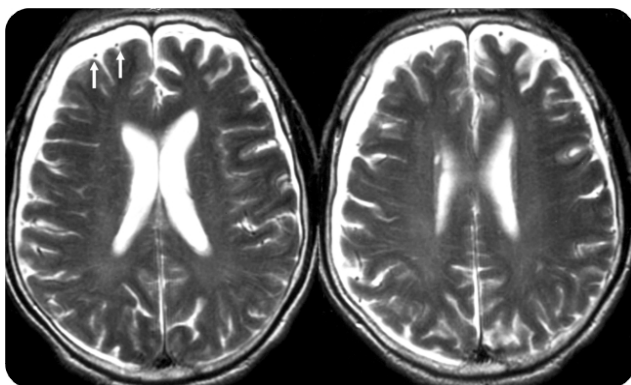


Fig. 4. If there is a cortical vessel (white arrows) below the extracerebral collection, the lesion will be subdural hygroma.

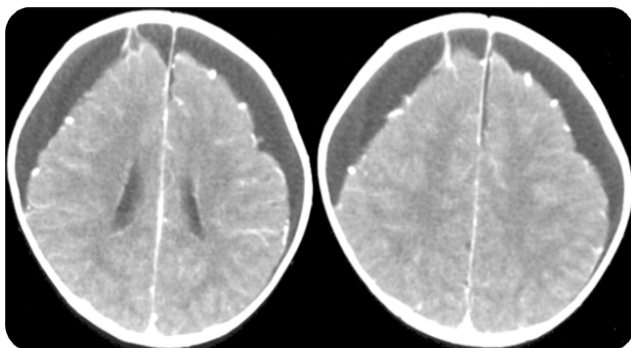


Fig. 5. The cortical veins can be seen even in contrast enhanced computed tomographic scans.

However, the cortical vein sign itself is not helpful to differentiate the subdural and the arachnoid spaces, especially around the sagittal sinus (Fig. 5).



CONCLUSION

Visualization of the cortical veins or vascular flow-void areas in the pericerebral fluid spaces is not useful to differentiate subdural hygroma and atrophy.



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