EDITORIAL COMMENT

Magnetic Resonance Venography of Intracranial Venous Diseases

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Over the past decade, neurologists and neuroradiologists have paid increasing attention to the role of the intracranial venous system in cerebrovascular diseases, such as dural sinus steno-occlusive diseases. The intracranial venous system has been evaluated traditionally during the venous phase of conventional catheter digital subtraction angiography (DSA). In fact, DSA is still the gold standard investigation of intracranial venous anatomy and the most definitive diagnostic technique for intracranial venous disease. The advantages of DSA include widespread availability, excellent spatial resolution, familiarity of the images to clinicians, and, most importantly, its inherent option of endovascular intervention and thrombolysis for cerebral venous thrombosis. However, DSA is an invasive procedure with well-known associated risks such as cerebral infarction, vascular wall injury and hematoma at the puncture site.[1] A short post-procedural hospital stay, radiation exposure, allergic or nephrotoxic effects of iodinated contrast medium, and the limitations of 2-dimensional (2D) planar imaging are additional disadvantages.[2] For these reasons, the use of noninvasive imaging techniques in the evaluation of the intracranial venous system is gradually increasing.

Noninvasive imaging techniques include cerebral computed tomographic venography (CTV) and magnetic resonance venography (MRV). Widespread availability and a more rapid image acquisition which reduces the effect of patient-related motion artifacts are the advantages of CTV over MRV. However, CTV is similar to catheter DSA in requiring the use of iodinated contrast medium and radiation exposure. CTV also requires complex post-processing to remove the bony structures from the reconstructed images; thus, visualization of skull base structures is limited.[2,3] Therefore, CTV always provides a supportive role while there is increasing reliance on MRV.[2] In spite of the disadvantages of decreased spatial resolution, slightly lower sensitivity and specificity for vascular patency relative to DSA, contraindications to magnetic resonance (MR) imaging study such as pacemaker and ferromagnetic foreign bodies in critical locations (e.g. eye, brain and lung), MRV is still the current method of choice for imaging the intracranial venous system. Although individual MRV techniques have some artifacts and potential diagnostic pitfalls,[2–7] good correlation has been shown between MRV and DSA.[4]

There are 3 magnetic resonance angiography (MRA) methods commonly available for evaluating the intracranial venous system: 2D time-of-flight (TOF), 3-dimensional (3D) phase-contrast (PC) and 3D gadolinium-enhanced (GE) pulse sequences. 2D TOF MRA is based on the principle of flow-related enhancement and highlights differences in magnetization between nuclei in flowing blood and those in stationary tissue. 2D TOF MRA is sensitive to slow flow and does not require an injection of contrast medium. Its main disadvantages include insensitivity to in-plane flow due to saturation effects, which cause artifactual signal loss at predictable locations (i.e. posterior sagittal sinus, transverse sinus, and transverse sigmoid junction),[8] patient motion that causes vessel misregistration among the slices, and high signals from background substances with short T1 values (e.g. fat, methemoglobin and gadolinium) on reconstructed images.[2,3] The presence of the artifactual signal loss may increase the difficulty in confidently discriminating a hypoplastic from a thrombosed dural sinus. PC MRV uses velocity-induced phase shifts, which are proportional to the velocity of flow, to depict flowing blood. PC MRV

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has the ability to quantify flow and determine flow direction. However, the relatively long acquisition times (>15 minutes) and the need to predict the optimal velocity encoding variable, which is generally not known in advance, make this imaging technique complicated to execute successfully.[2,3] 3D GE MRV with the paramagnetic effect of gadolinium shortens the intravascular T1 relaxation time, thus increasing the signal intensity of blood, with no saturation effects. The contrast between blood and stationary tissue becomes relatively flow-independent, and the contrast enhancement of the intravascular space produces a "luminogram" on 3D GE MRV in a manner analogous to conventional catheter angiography.[2,3] High-quality 3D GE MRV provides reliable luminograms of the dural sinuses to depict clearly the intraluminal structures such as arachnoid granulations or trabeculations (Willis cord).[9] For optimal image quality, the injection profile must be set when the contrast bolus is maximally present within the vessels of interest during image acquisition. Too early or too late acquisition might miss the peak passage of contrast bolus, and produce inadequate visualization of the vessels. Therefore, MR-compatible injectors and software for automated bolus tracking to trigger image acquisition should be employed. The major advantages of 3D GE MRV are the superior visualization of intracranial venous morphology, a faster acquisition time which reduces patient-related motion artifacts on the images, and avoidance of saturation effects that are often problematic with TOF techniques. Although 3D GE MRV incurs the cost of the contrast agent, the power injector and supplies, patient discomfort of obtaining antecubital intravenous access, and training the MR technologists, these disadvantages are minor in comparison with the cost and potential morbidity of DSA. There are several methods to detect and trigger the optimal timing for contrast injection during image acquisition of 3D GE MRV.[5] There have also been many reports comparing 3D GE MRV with TOF or PC MRV.[5–7,10] Fu et al have successfully used a real-time triggering method, in which the 3D GE MR angiographic sequence was initiated precisely when contrast medium was filling in the superior sagittal sinus.[10] Therefore, 3D GE MRV is superior to 2D TOF MRV in the provision of more detailed and high-quality images of the intracranial venous system, and because it can lead to better diagnosis of venous diseases. Time-resolved GE MRV is another new technique, in which images are repeatedly acquired from a volume during the passage of contrast medium, to allow acquisition of multiple 3D image sets.[11] The dynamic visualization of intracranial vessels can be used in cases of arteriovenous malformations and dural arteriovenous fistulas for detecting early feeding arteries and draining veins. The advantage of this technique is that the acquisition of images can start coincident with or shortly after initiation of contrast agent injection, with no need for triggering systems.

When available, 3D GE MRV is the method of choice for the diagnosis of dural sinus thrombosis, as well as most other pathological entities that affect the intracranial venous system. It has superiority to 2D TOF MRV in the diagnosis or exclusion of acute dural sinus thrombosis in daily clinical practice. Cerebral venous and sinus thrombosis can present with a variety of clinical symptoms, ranging from isolated headache to severe coma. Early diagnosis is very important as anticoagulation can reduce the risk of a fatal outcome or severe disability.

In the case of brain tumors, information on the intracranial venous system is crucial and helpful for surgery. To assess the patency of dural sinuses is very important in extra-axial tumors, especially parasagittal meningioma. Moreover, cortical veins are important landmarks in craniotomy, for example, in the case of the transcallosal approach. 3D GE MRV is useful in visualizing the patency of major dural sinuses and localization of cortical draining veins on preoperative evaluation of brain tumors.[12] The major pitfall of 3D GE MRV in imaging the intracranial venous system, compared with conventional angiography, is its inability to recognize venous collateral vessels during preoperative evaluation of brain tumors. Time-resolved 3D GE MRV has recently received considerable attention for dynamic visualization of cerebral vessels, similar to DSA.[11] Not only has MR become the modality of choice for examining the venous system in patients suspected of having dural sinus thrombosis, but it has also been shown that 3D GE MRV can be used to diagnose idiopathic intracranial hypertension (pseudotumor cerebri), which is strongly associated with narrowing of the distal transverse sinuses,[2,13] and intracranial hypotension, which always demonstrates enlargement of the dural sinuses,[2] a compensatory mechanism that responds to the loss of intracranial volume and pressure.[14]

In conclusion, advances in the pulse sequences of MRV, especially 3D GE MRV, which offers excellent visualization of venous morphology from multiple orientations, have made it possible to visualize intracranial venous diseases, e.g. dural sinus thrombosis (no flow), dural sinus stenosis (slow flow), and dural arteriovenous fistula, arteriovenous malformation, and intracranial hypotension (high flow), without the use of invasive techniques or ionizing radiation.

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