Review Article

Cerebral angiography and venography for evaluation of Cerebral Venous Thrombosis

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Abstract

Cerebral venous thrombosis is an uncommon, but important cause of stroke due to its high morbidity. Though conventional catheter based angiography is becoming replaced by newer, noninvasive imaging modalities, it still plays an important role in the evaluation of patients with suspected sinus or venous thrombosis.

Techniques of angiography, normal anatomy and variants, and pathological drainage patterns are discussed in reference to thrombosis of the major dural and cortical venous structures.

Knowledge of the normal drainage patterns of the cerebral venous system is essential in interpreting angiographic information obtained in the evaluation of patients with suspected cerebral venous thrombosis.

Introduction

Cerebral venous thrombosis (CVT) causes less than 1% of all strokes,[1-3] but is particularly devastating in its predilection for younger patients. Autopsy data have revealed an incidence of 16 among 12,500 patients (<1%)[4] to 9%.[5,6] In the past, mortality rates as high as 30-50% were reported, though more recent, controlled studies have found mortality rates under 11%.[7]

Though considered the gold standard in evaluation of the vasculature of the nervous system, angiography and venography are becoming replaced by newer techniques, namely magnetic resonance imaging (MRI) and venography (MRV) for the evaluation of cerebral venous thrombosis (CVT). However, conventional catheter based angiography still has a role in the diagnosis of CVT, particularly when evaluation of smaller cortical veins is necessary, as in arteriovenous fistulae, in which retrograde filling of cortical veins and subsequent thrombosis may occur as the primary symptom producing consequence of the disease. Additionally, a proportion of patients who progress despite heparin therapy[8,9] may require angiography for the purposes of endovascular thrombectomy or fibrinolysis.[11-13]

Knowledge of the venous and dural sinus anatomy, their normal variations, and the disease conditions in which thrombosis of these vasculature structures may occur is essential to correct interpretation of the angiographic information in conditions of suspected venous thrombosis.

Techniques of angiography and normal venous anatomy

Evaluation of the dural sinuses should entail selection of at least one vessel from the anterior circulation and one from the posterior circulation. Due to asymmetry and preferential flow patterns, it is ideal to catheterize both carotid arteries. Furthermore, a full three to four vessel angiogram is essential for evaluation of the cortical venous system. Biplane digital subtraction angiography with prolonged exposure into the late phase of injections provides excellent resolution with post-acquisition adjustment capabilities. Standard anterioposterior (AP) and lateral views should be obtained, which best delineate the superior sagittal sinus (SSS) and transverse sinus (TS) systems and other midline vasculature, which may then be supplemented by obliqued AP views to allow for displaying of the two transverse sinuses and the proximal and distal points of the SSS.

Review of angiographic images for evaluation of the cerebral venous system should include inspection for filling of the major dural sinus system including the SSS, inferior sagittal sinus (ISS), superior petrosal sinus (SPS), inferior petrosal sinus (IPS), cavernous sinuses (CS), bilateral TS, sigmoid sinuses, occipital sinus (OS), and straight sinus (SS). As the SSS, ISS, and CS receive drainage from the

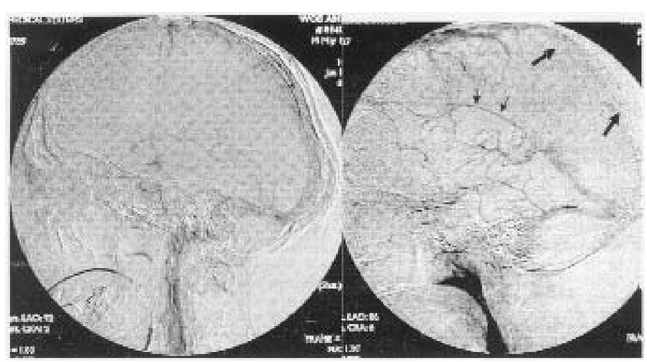

Figure 1-A. Right internal carotid artery (ICA) injection, lateral view demonstrates hypoplasia of the anterior third of the superior sagittal sinus (SSS). The normal parasagittal cortical veins draining into the posterior two-thirds of the sinus are not seen anteriorly.
Figure B. A different patient's left ICA angiogram, lateral view. The caudal portion of the SSS (large arrows) is not visualized, and in contrast to panel A, the cortical veins in the anterior portion are prominent, as is the inferior sagittal sinus (small arrows).

Figure 2. Left vertebral artery angiogram in a patient with a posterior fossa dural arteriovenous malformation demonstrates normal filling of the left transverse sinus with impaired flow through the right transverse sinus (arrows).

anterior circulation and thus will be visualized upon injection of the carotid arteries, while the OS, SPS, IPS, and SS receive tributaries arising from the posterior fossa structures, and are visualized upon vertebral artery injection. The transverse sinuses, also referred to as the lateral sinuses, receive drainage from the SSS as well as from cerebellar hemispheric veins, so may be seen on the late phase of both anterior and posterior circulation injections. In addition the TS receive tributaries from the occipital and temporal lobes, including the vein of Labbe, and the tentorium. The skull base dural sinuses (SPS, IPS, CS, as well as sphenoparietal sinus) are variable and not always visualized angiograhically.[14]

The SSS is subject to marked variability. The proximal one-third to one-half may be hypoplastic or absent in normal individuals (Figure 1-A), and if identified during angiography should be evaluated in the light of the clinical context. Absence of cortical veins draining into this portion may help differentiate congenital absence of the proximal SSS from de novo thrombosis. In such situations, there may be one large posterior frontal parasagittal vein which serves as the predominant mode of venous drainage of that region (Figure 1-B). On standard biplane angiography, the SSS is

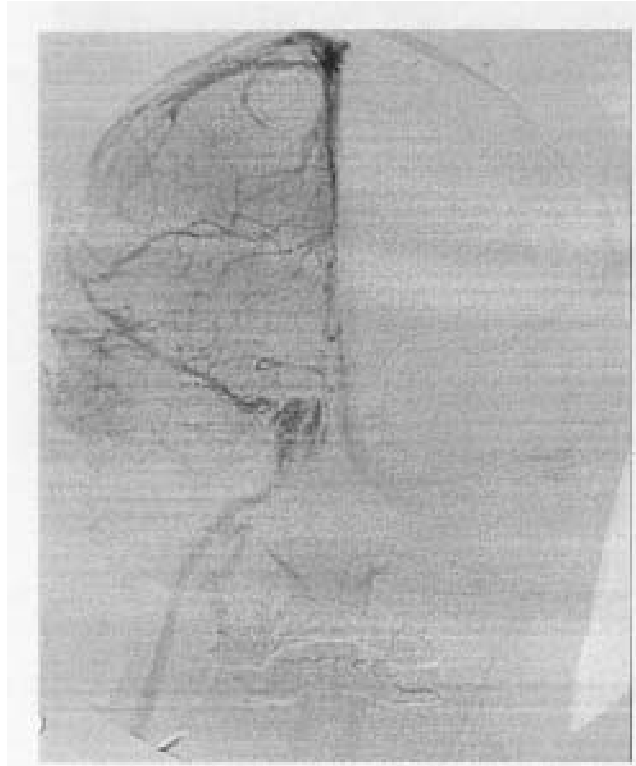

Figure 3. Right internal carotid artery angiogram in patient with right transverse sinus thrombosis and dural arteriovenous fistula formation demonstrates retrograde drainage through the superficial middle cerebral vein (arrow).

more readily visualized on lateral plane imaging, as straight AP imaging will result in superimposition of the anterior and posterior aspects. However, a few degrees right or left oblique will display the proximal and distal points of the SSS and allow for visualization of its origin and endpoint as it empties into the sinus confluence.

Similarly, widespread variation exists in the appearance of the TS, more readily appreciated on AP imaging. In the majority of people, codominance of the bilateral TS is seen, whereas in 25%, the right TS is dominant. Left dominance and unilateral hypoplasia are seen in an equal number

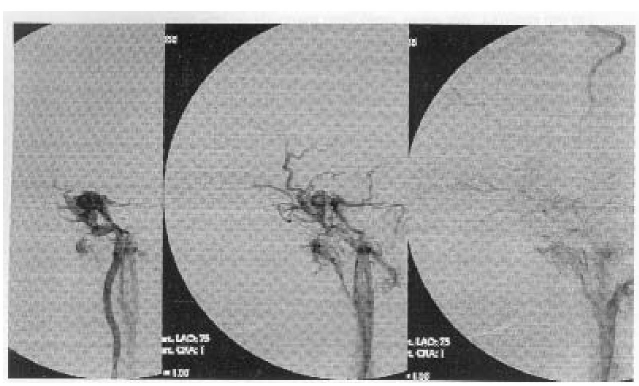

Figure 4. Right internal carotid injection in patient with carotid cavernous fistula. Though there is no thrombosis in the cavernous sinus (CS), the successive injections from arterial to venous phase demonstrate retrograde flow through the superior and inferior ophthalmic veins (arrows) as may be seen in CS thrombosis.

as those with right dominance, and should be recognized as such, so as not to be mistaken for pathology. An induced Valsalva maneuver, easily accomplished by asking the patient to maintain a deep inspiration, increases the thoracic venous pressure, obstructing IJ efflux from the cranial vault, which may augment flow through an otherwise unapparent TS. Interpretation of this filling in a pressurized system must still be weighed in the clinical context, as a congenitally hypoplastic TS may be just as likely to open with increased retrograde venous pressures as a partially thrombosed TS.

The sigmoid sinus is the continuation of the TS as it drains into the internal jugular (IJ) vein. Each TS receives venous drainage from the cerebellar hemispheres, and though drainage may flow across the contralateral sinus, a unilateral thrombosis of the TS (Figure 2) may still pose a risk for haemorrhage. Where unilateral hypoplasia of the TS exists, the corresponding sigmoid sinus, and even the IJ, may also be hypoplastic or absent. Thrombosis of the IJ due to in-dwelling central venous catheters, is not infrequent among chronically hospitalized patients, and may be recognized on conventional angiography as being asymmetrical in appearance compared with larger caliber of the patent proximal TS and sigmoid sinuses (unless thrombosis extends retrograde to involve these structures). This usually is not of clinical concern as the contralateral IJ will adequately drain the system via the torcular Herophili sinus confluence.

The smaller skull base dural sinuses are subject to more inconsistency and are more difficult to visualize on conventional angiography. However, their appearance may become more manifest in the presence of asymmetry due to underlying pathology. In this case, knowledge of the disease conditions which lead to fistulous formations between arterial structures and these sinuses or abnormal retrograde flow through these sinuses become important and are briefly discussed here.

The smaller cerebral veins are much less easily differentiated on angiography. If thrombosis of cortical veins is suspected, then selection of both internal carotid (or vertebral) arteries may be necessary, as only one side will lead to filling of the venous system in question, while the other, normal, side is necessary for comparison. Systemic inspection of the cerebral veins, as with the dural venous system, involves knowledge of the anatomy.

For ease of consideration, they may be divided into three groups as superficial (cortical), deep (subependymal), and those of the posterior fossa.[15] The single most important advantage of real time conventional angiography over other imaging modalities for evaluation of CVT is the visualization of the direction of flow in the venous system. Change of flow patterns may be seen in conditions of abnormal arteriovenous fistulae with thrombosis of larger channels, creating increased pressure demands on the second order smaller venous system. Typical drainage occurs from the smaller cortical or other cerebral veins, into the larger, low pressure dural sinus system. For instance, the anastamotic vein of Trolard receives drainage from the superficial middle cerebral vein (SMCV) and then courses to the SSS, while the anastamotic vein of Labbe connects the SMCV to the TS. In conditions of thrombosis of either of these sinuses, the corresponding superficial vein may be seen to flow retrograde, away from the dural sinus rather than towards it (Figure 3).

The smaller deep cerebral veins are even more difficult to discern on angiography. Many are unnamed, but of the more constant ones, they may be divided into medullary veins and the subependymal veins into which they drain. The medullary veins drain into the latter group at right angles, receiving outflow from the frontal and parietal lobes. The more important subependymal veins include the septal veins, which flow from the frontal horn to the genu of the corpus callosum to drain into the internal cerebral veins; the thalamostriate veins, which are formed by the confluence of the anterior caudate veins and the terminal vein, also helping to form the internal cerebral veins which themselves are the largest of the deep cerebral veins, which ultimately drains into the deep dural sinus, anomalously referred to as the great vein of Galen. The vein of Galen also receives drainage from another important vein, the basal vein of Rosenthal, which in turn receives drainage from a confluence of the deep and middle cerebral veins, before emptying into this primitive dural sinus. The vein of Galen continues into the straight sinus after joining with the ISS. The deep venous system is best seen on late angiography, by which time the overlying cortical veins may have emptied and are unopacified. If thrombosis of the deep venous system is suspected, attention must be given to longer exposure times during angiography.

Important drainage patterns in CVT

Thrombosis of the larger sinus systems and cerebral veins bears its brunt on the smaller veins which usually form tributaries to these larger structures. Retrograde drainage patterns through different superficial and deep cerebral networks can be appreciated on real time angiography and are important pathognomic consequences of coexisting dural venous thrombosis. Therefore, knowledge of normal drainage patterns, such that reversal of flow may be readily noted, is of paramount importance in evaluating patients with CVT.

Typically, blood from the orbits follow the path from the high resistance globe to the lower resistance cavernous sinus system via the superior and inferior ophthalmic veins. However, in conditions of cavernous sinus thrombosis, reversal of flow along these venous channels occurs (Figure 4), which may result in visual loss if untreated.

As stated above, the SSS receives multiple parasagittal convexity veins as well as the vein of Trolard. Retrograde filling in the vein of Trolard may occur as a sequelae of SSS thrombosis, and its presence may help differentiate a thrombosed SSS from an anteriorly hypoplastic variant.

Similarly the cerebellum and temporal lobes deliver their predominant drainage through the TS system. Thrombosis of the TS may manifest as retrograde drainage through the vein of Labbe or other posterior fossa veins, and again is an important clue to differentiate between congenital hypoplasia of one TS versus true thrombosis. Though the superior group of veins of the posterior fossa drain into the vein of Galen, thrombosis of the latter is less common than that of the TS, and so usually is not seen in isolation.

The posterior fossa veins are best seen on lateral plane imaging during angiography except for the petrosal vein which receives tributaries from the cerebellum, pons, and medulla before itself entering the superior petrosal sinus.

In general, thrombosis of the cortical veins in absence of thrombosis of the larger dural sinuses, is best appreciated by an asymmetrical appearance of the filling of these compared with their counterparts on the contralateral hemisphere. However, as with the dural sinuses, laterality in dominance exists with some of the larger veins, particularly the vein of Trolard, being more prominent in the dominant hemisphere, and the vein of Labbe, typically more prominent in the nondominant hemisphere. However, a complete lack of drainage of a region of a cerebral or cerebellar hemisphere, compared to the drainage pattern of the contralateral side, should be regarded as abnormal.

Conclusion

Angiography for the evaluation of CVT is becoming increasingly replaced by newer, noninvasive imaging modalities such as MRI/MRV, but still is important in demonstrating thrombosis of smaller cortical veins. Asymmetry of venous drainage between the two hemispheres as well as retrograde flow seen on real-time angiography are key angiographic features of underlying venous thrombosis. Knowledge of the normal venous anatomy including patterns of drainage of the cerebral veins into the dural sinus system is paramount to correctly interpreting angiographic data in the diagnosis of CVT.

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