Anatomy and Frequency of Large Pontomesencephalic Veins on 3D CT Angiograms of the Circle of Willis

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BACKGROUND AND PURPOSE: The pontomesencephalic veins (PMVs), especially the anterior PMV, are sometimes large enough that they could potentially affect the interpretation of CT angiograms of the circle of Willis. We investigated the frequency and anatomy of visible PMVs on 3D CT angiograms.

METHODS: CT angiograms of 211 consecutive patients who underwent CT angiography for a variety of clinical indications were evaluated retrospectively. Images evaluated by consensus between two neuroradiologists were maximum intensity projection and volume-rendered 3D CT angiograms.

RESULTS: Visible PMVs were present on 3D CT angiograms in 11 (5.2%) of 211 patients. Eight of 11 patients had a visible anterior PMV behind the basilar artery. In four patients, the venous caliber of the anterior PMV was sufficiently large enough to be potentially confused with arterial structures. In one patient, 3D CT angiography revealed a large anterior PMV (~2.6 mm in diameter) in the interpeduncular cistern, which had been mistaken for subarachnoid hemorrhage on a nonenhanced CT scan. Two patients had interpeduncular veins of the anterior PMV draping over the dome of a basilar tip aneurysm. In only one patient was the anterior PMV visible possibly owing to arteriovenous malformation. One patient had visible lateral mesencephalic veins, and four patients had visible transverse pontine veins. In one case, on certain views, the transverse pontine veins appeared to arise from the basilar artery.

CONCLUSION: Because of their small size, PMVs were seen only infrequently on 3D CT angiograms, but neuroradiologists should be familiar with the normal variants of large PMVs to avoid diagnostic and anatomic confusion.

Three-dimensional CT angiography has been more widely used in recent years, with numerous reports of its utility in the detection and evaluation of aneurysms of the circle of Willis (1–4). Because of the acquisition technique, this imaging modality depicts both arterial and venous structures. It is not uncommon to see prominent venous structures about the circle of Willis.

The pontomesencephalic veins (PMVs) consist of the pontine veins, which run along the ventral surface of the pons; the interpeduncular veins, which run along the surface of the cerebral peduncles; and the lateral mesencephalic veins, which are localized in the lateral mesencephalic sulci (5). Occasionally, there may be only a single longitudinal vein, which is called the anterior PMV and which runs in the interpeduncular fossa and on the superior and anterior aspects of the belly of the pons between the basilar artery and the brain parenchyma in or adjacent to the midline (6).

The PMVs, especially the anterior PMV, may sometimes become large enough that they may obscure the arterial structures on CT angiograms. Thus, they could potentially affect the interpretation of CT angiograms of the circle of Willis or surgical planning. We retrospectively investigated the frequency and anatomy of visible PMVs on maximum intensity projection (MIP) and volume-rendered 3D CT angiograms.

Methods

We retrospectively reviewed the CT angiograms of 211 consecutive patients who underwent CT angiography for a variety of clinical indications between September 1997 and November 2000. Three-dimensional CT angiography was performed with 1-mm collimation on single–detector row and 0.5-mm collimation on multi–detector row helical CT scanners (Somatom Plus...
There was no noticeable difference between size of disk level or volume-rendering workstation settings, although visibility was somewhat dependent on window and level settings of the workstation. Afterward, the neuroradiologist could manipulate the images in a near-infinite number of projections with varying amounts of time needed for review (usually 5–10 minutes). The 3D volume-rendered and MIP images were evaluated by consensus between two neuroradiologists (M.T., S.C.) for conspicuity of PMVs. Although not used to quantitate the frequency of large visible PMVs in this study, source images and multiplanar reformations were also reviewed on the workstation. These images consistently allowed visualization of the typical tiny PMVs that were easily distinguishable from the arteries of the circle of Willis. Such tiny PMVs only resulted in small, incomplete or spotty venous structures on 3D volume-rendered and MIP CT angiographic views.

Results

In 11 (5.2%) of 211 patients, PMVs were visible as venous structures on 3D CT angiograms. Visibility corresponded with a caliber of 0.9 mm or greater, although visibility was somewhat dependent on window level or volume-rendering workstation settings. There was no noticeable difference between size of the venous structures seen on 1.0-mm acquisitions versus 0.5-mm acquisitions. The reviewing neuroradiologists did not notice any difference in identifying prominent venous structures between techniques with a pitch of 1.0 versus a pitch of 1.5 or on the single–detector row versus the multi–detector row CT scanner. The injection rate was 5 mL/s for a total scanning time of 15–20 seconds on the multi–detector row CT scanner. The total volume of iohexal (Omnipaque) was typically 100 mL. The x-ray tube potential and current were approximately 120 kV and 200 mA, respectively. Table speed for single–detector row and multi–detector row scanners were 1.33–2 mm/s and 2–3 mm/s, respectively. Pitch varied from 1 to 1.5. Scan revolution times of 0.75 second for single–detector row and 0.5 second for multi–detector row scanning were used. Three-dimensional reconstructions were performed on Vital Images Vitrea 2 workstations (Vital Images Inc., Plymouth, MN) by using preset volume-rendered and MIP display algorithms. Notwithstanding the network transfer time of source image data, it took approximately 2–3 seconds to generate the 3D reconstructions on the workstation. Afterward, the neuroradiologist could manipulate the images in a near-infinite number of projections with varying amounts of time needed for review (usually 5–10 minutes). The 3D volume-rendered and MIP images were evaluated by consensus between two neuroradiologists (M.T., S.C.) for conspicuity of PMVs. Although not used to quantitate the frequency of large visible PMVs in this study, source images and multiplanar reformations were also reviewed on the workstation. These images consistently allowed visualization of the typical tiny PMVs that were easily distinguishable from the arteries of the circle of Willis. Such tiny PMVs only resulted in small, incomplete or spotty venous structures on 3D volume-rendered and MIP CT angiographic views.

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In one of 11 patients, lateral mesencephalic veins were visible. Four of 11 patients had visible interpeduncular veins of the anterior PMV (Fig 2). In only one patient was the anterior PMV visible, possibly owing to a pathologic cause. This patient had an arteriovenous malformation although drainage was not directly into the anterior PMV. In one of 11 patients, lateral mesencephalic veins were visible. Four of 11 patients had visible transverse pontine veins. In one patient, the transverse pontine vein appeared to arise from the basilar artery and was potentially confused with the anterior inferior cerebellar artery in certain views (Fig 3).
Discussion

During the fourth stage of embryonic development, primitive veins first become identifiable and pass transversely through the pia-arachnoid to reach the dural layer of vessels. Between these primary venous elements, secondary longitudinal anastomoses soon develop on the neural tube and regularly proceed subjacent and at right angles relative to the more developmentally advanced arteries stemming from the midline or nearby. Such longitudinal veins in turn are connected by transverse anastomoses across the midline beneath the basilar artery (5).

The anterior PMV is one of the longitudinal venous channels on the anterior aspect of the brain stem (Fig 4). When it is located in or adjacent to the midline, it is called the median anterior PMV. This median anterior PMV outlines the profile of the depth of the interpeduncular fossa and anterosuperior aspect of the belly of the pons. Sometimes, the anterior PMV runs parasagittally on the anterior aspect of a cerebral peduncle and on the anterolateral aspect of the pons (5–9). These veins, unlike the arteries, are always strongly adherent to the pons (10). This relation was of great importance to neuroradiologists before the advent of cross-sectional brain imaging. This was because these veins traced the silhouette of the pons and the mesencephalon on conventional angiograms and could, thus, be used to indirectly detect intrinsic brain stem lesions (11, 12). In recent times, the brain stem venous anatomy has been of little interest to radiologists. How-
ever, if these veins are large enough, they may rarely cause some diagnostic difficulties on cross-sectional images. One of our patients had a large anterior PMV, which was confused with subarachnoid hemorrhage because of its location in the interpeduncular cistern, the typical location of nonaneurysmal perimesencephalic hemorrhage (anterior to the brain stem) (13). In this patient, CT angiography helped us to differentiate the large anterior PMV as the cause of hyperattenuation in the interpeduncular cistern (Fig 1), and the patient did not need to undergo any further diagnostic tests.

Awareness of venous anatomy is also important in the interpretation of CT angiograms. With the increasing use of CT angiography of the circle of Willis, radiologists will need to become more familiar with the anatomy of the PMVs. This is because on CT angiograms, unlike MR angiograms on which a saturation band renders the veins invisible, the veins are generally opacified unlike MR angiograms on which a saturation band renders the veins invisible, the veins are generally opacified on CT angiograms because it may sometimes be large enough potentially to be confused with adjacent arteries such as the anterior inferior cerebellar artery.

Conclusion

Because of their small size, PMVs only infrequently appear on 3D CT angiograms (5.2% of patients in our series), but neuroradiologists should be familiar with the normal variants of large PMVs to avoid diagnostic and anatomic confusion. In addition, false-positive nonenhanced CT scans for subarachnoid hemorrhage with a nonaneurysmal perimesencephalic pattern may occur owing to a normal variant of a large anterior PMV in the interpeduncular cistern.

References