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Sonographic Characteristics of the Cavum Velum Interpositum

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BACKGROUND AND PURPOSE: Differential considerations for pineal region CSF collections include both true cysts and normal cystlike anatomic variations. Our purpose was to determine the sonographic characteristics of pineal region fluid spaces that reflect the presence of a normal persistent cavum velum interpositum (CVI).

METHODS: Eighteen neonates and infants who had sonographic findings of “cysts” in the pineal region were examined prospectively with conventional sonography and color Doppler sonography to evaluate the shape of the fluid collection and its anatomic relationship with the color-coded internal cerebral veins. Subsequent MR images were obtained in eight of these infants to determine the exact nature of the cystlike collections.

RESULTS: The cystlike spaces in the pineal region were of an inverted helmet shape in 14 subjects and roundish in four. All were situated inferior or slightly anteroinferior to the splenium of the corpus callosum and 2.5 to 4 mm away from the quadrigeminal plate. The internal cerebral veins were either inferior ($n = 12$) or inferolateral ($n = 6$) to the cystlike spaces at sonography. Subsequent MR studies confirmed eight of these cystlike spaces to be the posterior portion of the CVI.

CONCLUSION: The CVI may appear as a cyst in the pineal region on neonatal sonograms. Usually, it has a characteristic inverted helmet shape and is situated beneath the fornices and above the internal cerebral veins.

The cavum velum interpositum (CVI) represents a potential space above the tela choroidea of the third ventricle and below the columns of the fornices (Fig 1A) (1, 2). The anatomic location of the CVI is in close approximation to the crus of the fornices and the splenium of the corpus callosum in the pineal region (Fig 1B and C). Recently, we encountered cystlike structures in the pineal region on routine cranial sonograms, mainly in preterm infants. Because the pineal gland is normally surrounded by the echogenic nondistended quadrigeminal cistern, a sonolucent structure seen in this region may raise concerns about the presence of an arachnoid cyst or pineal gland cyst, the latter of which is relatively uncommon in children, occurring in only 0.6% of routine MR studies relative to 2.6% in the adult population (3). To obviate a potential dilemma of diagnosing a true cystic lesion on an otherwise routine cranial sonogram, it is important to determine whether a cystlike structure within the area of the

pineal region and quadrigeminal cistern is an anatomic variant of the CVI. In this prospective study, we used color Doppler sonography and MR imaging to determine which characteristic features of these fluid spaces represent a CVI.

Methods

High-resolution sonography was used to prospectively image 87 consecutive infants, ranging in age from 25 weeks' gestation to 10 months. Indications for the sonographic examination were one or more of the following: prematurity ($n = 27$), respiratory distress syndrome ($n = 19$), seizure ($n = 21$), fever ($n = 15$), encephalopathy ($n = 13$), and possible hypoxic-ischemic brain injury ($n = 29$). Among these, 18 infants (ages 29 weeks' gestation to 6 months) who had a sonolucent cystlike structure in the pineal region were selected for further investigation with color Doppler sonography. Eight of these patients also had a subsequent MR examination. Informed consent was obtained for all infants undergoing an MR study.

Sonography was performed with a scanner equipped with a 5- or 7-MHz sector transducer. The color Doppler venous signal was optimized with parameters as follows: color persistence was at the maximal setting, the band-pass filter was at the minimal setting (125 Hz), and the color scale was at the lower setting (3–12 cm/s). Color gain was set individually to maximize vascular signal and to minimize tissue-motion artifacts.

The maximal anteroposterior dimensions of the pineal region cystlike structures were measured as was the distance

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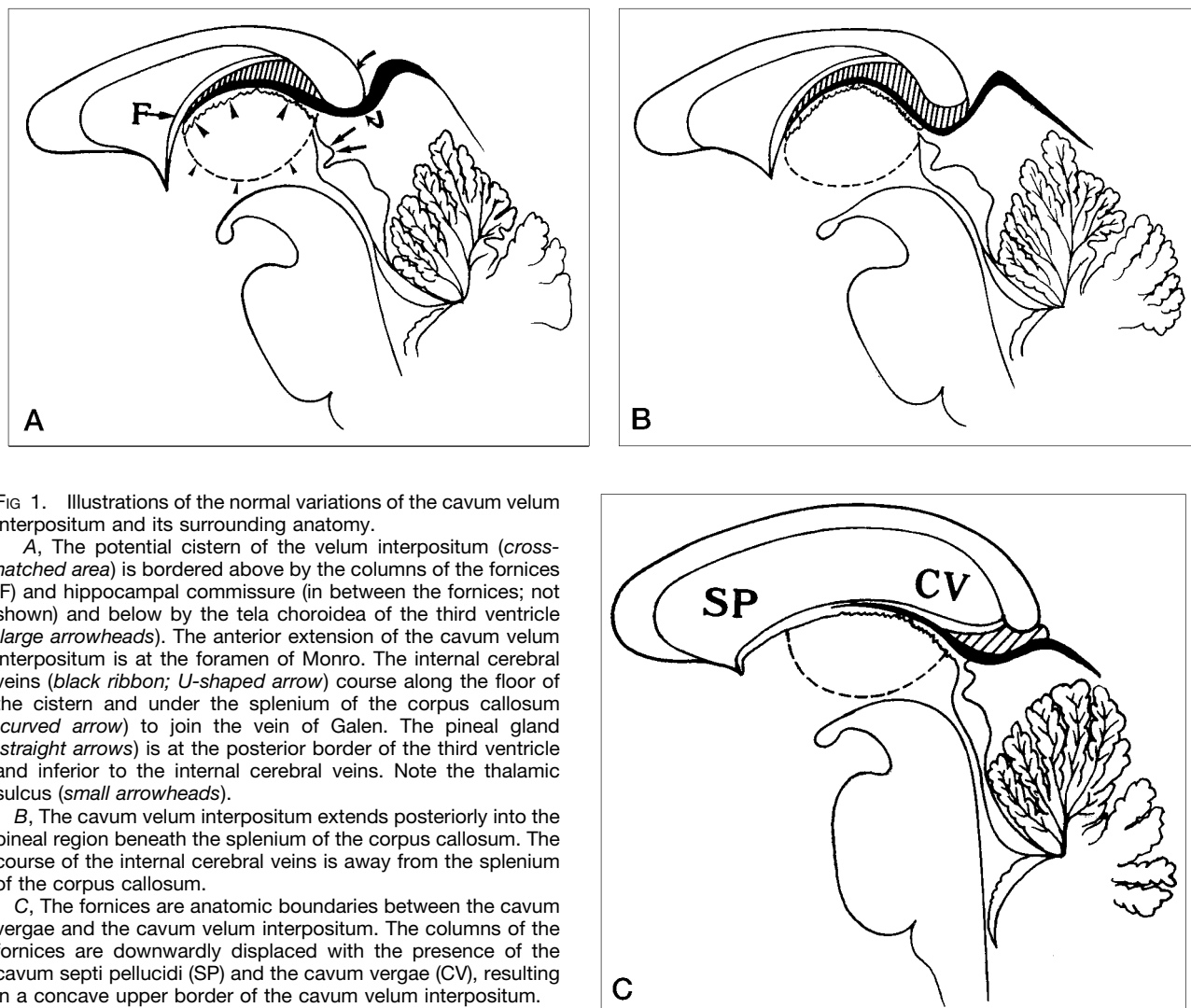


FIG 1. Illustrations of the normal variations of the cavum velum interpositum and its surrounding anatomy.

A, The potential cistern of the velum interpositum (cross-hatched area) is bordered above by the columns of the fornices (F) and hippocampal commissure (in between the fornices; not shown) and below by the tela choroidea of the third ventricle (large arrowheads). The anterior extension of the cavum velum interpositum is at the foramen of Monro. The internal cerebral veins (black ribbon; U-shaped arrow) course along the floor of the cistern and under the splenium of the corpus callosum (curved arrow) to join the vein of Galen. The pineal gland (straight arrows) is at the posterior border of the third ventricle and inferior to the internal cerebral veins. Note the thalamic sulcus (small arrowheads).

B, The cavum velum interpositum extends posteriorly into the pineal region beneath the splenium of the corpus callosum. The course of the internal cerebral veins is away from the splenium of the corpus callosum.

C, The fornices are anatomic boundaries between the cavum vergae and the cavum velum interpositum. The columns of the fornices are downwardly displaced with the presence of the cavum septi pellucidi (SP) and the cavum vergae (CV), resulting in a concave upper border of the cavum velum interpositum.

between the collection and the superior colliculus. Sonography and derived measurements were always performed by the same person. The sonograms and MR images were further interpreted by two neuroradiologists without knowledge of the ages or clinical history of the patients.

In the eight patients who had MR studies, imaging was performed at 1.5 T within 7 days after the color Doppler sonographic study. The imaging sequences consisted of spin-echo T1-weighted (500–600/15–40/1–2 [TR/TE/excitations]) axial, coronal, and sagittal images with a 3- to 5-mm section thickness and T2-weighted (2800–3000/90–120/1) axial or sagittal images with a 5-mm section thickness. Intravenous paramagnetic contrast material was not administered.

Results

Shape and Size of the Pineal Region Cysts

Eighteen infants had sonographic findings of a pineal region fluid collection, 14 of which had a characteristic inverted helmet shape with the convex side down and the flat side up on sagittal sonograms (Fig 2A). In the other four patients, the fluid collection was round. The fluid collections showed an inverted

triangular or roundish shape on posteriorly angled coronal images. The anteroposterior diameter of these cystlike structures on sagittal sonograms was 3 to 10 mm, with an average of 5.6 mm. Four of five collections that were larger than 8 mm were roundish in shape. The distance between the cyst and the quadrigeminal plate ranged from 2.5 to 4 mm.

All MR images in the eight infants showed enlargement of the cistern of the velum interpositum. The anatomic landmarks around the CVI, including the columns of the fornices, the splenium of the corpus callosum, the tela choroidea of the third ventricle, and the internal cerebral veins, were clearly depicted by MR imaging and sonography. MR imaging had the advantage of delineating the pineal gland with respect to the quadrigeminal cistern and the cystlike spaces of the CVI. The posterior portion of the CVI displayed on sagittal MR images corresponded well with the helmet-shape appearance of the CVI on sagittal sonograms (Fig 2C). The anteriormost extension of the CVI was identified at the foramen of Monro on MR studies. The pineal glands were either separated

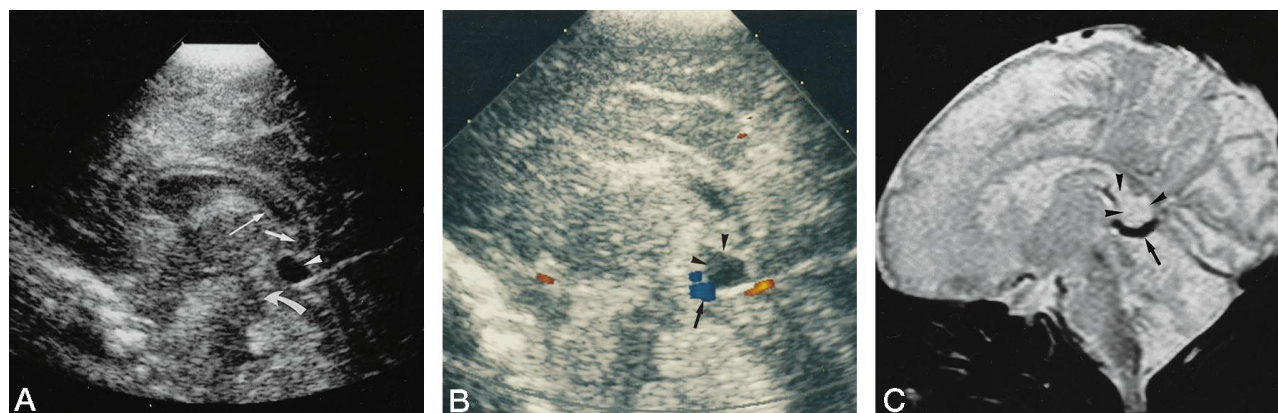


FIG 2. Normal sonographic and MR appearance of the cavum velum interpositum.

A, Midsagittal sonogram of a 33-week premature infant shows an inverted helmet-appearing cavum velum interpositum (arrowhead) situated below the splenium of the corpus callosum (short straight arrow) in the pineal region. The hypoechoic quadrigeminal plate (curved arrow) is 6 mm away from the cyst. Note the fornix (long straight arrow).

B, Corresponding color Doppler sonogram shows the inferiorly deviated course of the color-coded internal cerebral veins (arrow) away from the splenium of the corpus callosum and inferior to the cavum velum interpositum (arrowheads).

C, Midsagittal T2-weighted MR image (2800/90/1) of the same patient proves the cyst to be a prominent cavum velum interpositum. Note the flow-void internal cerebral vein (arrow) and the high-signal-intensity CSF space of the cavum velum interpositum (arrowheads).

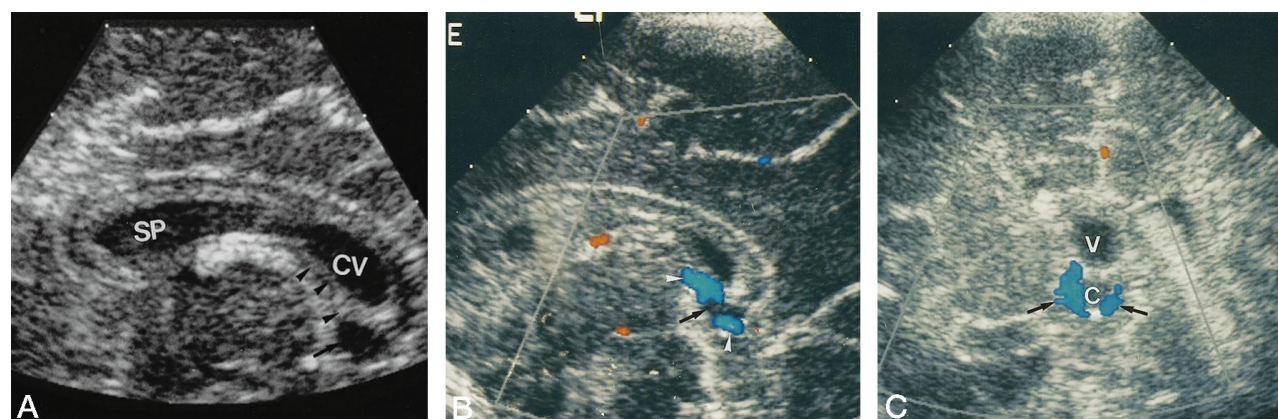


FIG 3. Presence of cavum septi pellucidi, cavum vergae, and cavum velum interpositum in a 32-week premature infant.

A, Midsagittal sonogram shows the downwardly displaced fornices (arrowheads) in between the cavum vergae (CV) and cavum velum interpositum (arrow). The cavum septi pellucidi (SP) is a CSF space anterior to the cavum vergae (CV) within the leaflets of the septi pellucidi.

B, Corresponding sagittal color Doppler sonogram shows the color-coded internal cerebral veins (arrowheads) anterior and inferior to the cavum velum interpositum (arrow).

C, Oblique coronal color Doppler sonogram depicts the lateral and inferior courses of the bilateral internal cerebral veins (arrows) with respect to the cavum velum interpositum (C). (V = cavum vergae).

from or in contact with the CVI. The CVI and the superior colliculi were separated by the quadrigeminal CSF space.

Location of the Internal Cerebral Veins

The color-coded internal cerebral veins were inferior and lateral to the pineal region fluid collections in 12 patients and directly lateral to the spaces in six patients on sagittal and coronal sonograms (Fig 2B). MR images of the eight infants revealed similar findings. The pineal gland was seen inferior to the internal cerebral veins on sagittal T1-weighted MR images in all eight cases. Observers' interpretations of the sonographic and MR findings of the CVI were in agreement for all eight patients. They also agreed in their interpretations of the sonographic findings concerning the shape and anatomic position of the CVI

with respect to the internal cerebral veins in the 10 infants who were not examined with MR imaging.

Presence of Cavum Septi Pellucidi and Cavum Vergae

Ten of the 18 infants with a CVI had a concomitant cavum septi pellucidi and six also had a cavum vergae. The cavum septi pellucidi and cavum vergae did not appear to displace or deform the CVI. The CVI was separated from the cavum vergae by the columns of the fornices (Fig 3).

Discussion

The CVI is a midline CSF space situated inferior to the hippocampal commissure (psalterium), antero-inferior to the splenium of the corpus callosum, and

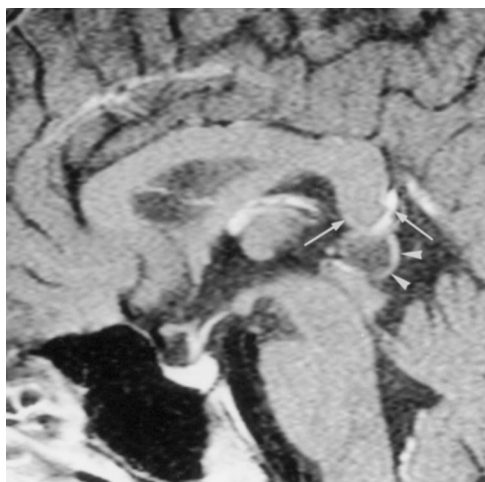


Fig 4. Enhanced sagittal T1-weighted MR image (600/15/2) shows a pineal cyst (arrowheads) that compresses the superior colliculus. The enhancing internal cerebral vein (arrows) is displaced upward against the splenium of the corpus callosum. The cistern of the velum interpositum is not identified.

superior to the tela choroidea of the third ventricle (Fig 1A). The columns of the fornices form the superolateral walls of the CVI and the thalami form the inferolateral wall. The most anterior extension of the CVI is at the foramen of Monro. Anatomically, the CVI is closely related to the internal cerebral veins. The paired internal cerebral veins normally lie adjacent to and course to the sides of the tela choroidea of the third ventricle and then are directed posteriorly under the splenium of the corpus callosum to join the vein of Galen (Fig 1A). They provide the anatomic landmarks of the CVI at its lateral and inferior borders. Posterior extension of the cavum to the pineal region under the splenium of the corpus callosum is accompanied by caudal deviation of the internal cerebral veins from the splenium (Fig 1B). The anterior extension of the CVI is best defined on sagittal T2-weighted MR images. The posterior extension of the CVI can be clearly seen as an anechoic inverted helmetlike structure on sagittal sonograms. The convex side of the helmet is formed by the internal cerebral veins, and the inlet of the helmet conforms to the shape of the inferior surface of the splenium. The cystlike CVI may be differentiated from true cystic lesions, such as arachnoid cysts in the quadrigeminal cistern, by the fact that the latter are topographically below the internal cerebral veins abutting the colliculus whereas the CVI is situated at a distance of 2.5 to 4 mm away from the quadrigeminal plate, as our findings show. Large cysts of the pineal region may displace the internal cerebral veins upward against the splenium of the corpus callosum and compress the tectum of the midbrain (Fig 4). Therefore, the position of the internal cerebral veins and the shape of the fluid spaces may provide useful information regarding the origin of the cyst. An arachnoid cyst arising from the CVI is extremely rare and can only be differentiated from a normal CVI by its unusually large size and abnormal shape. Among our patients, four had a round CVI with the internal

cerebral veins coursing directly lateral to it. These four CVIs were larger than the average size of those in the remaining 14 infants in the study. It may be that a slightly larger CVI appears to have a roundish shape instead of the typical helmet morphology. In the study by Picard et al (4), 20% of the CVIs were ovoid in shape by pneumoencephalography.

Embryologically, the CVI is a true cistern originating from the roof plate of the diencephalon by a process of the pia mater, which protrudes into the primitive neural tube at about the third fetal month. Other investigators have considered the CVI to be the result of an abnormal separation of the limbs of the fornices (5). Associated congenital midline anomalies of the brain with the CVI have not been described. In our study, 12 of the 18 infants were premature, which supports the observation that the CVI is part of a normal developmental process of the cerebral midline and decreases in size after full-term birth (4).

Clinically, the CVI is not an infrequent finding on routine imaging of the brain in young children (4). Early pneumoencephalographic studies show the CVI with a frequency of 34% in children younger than 2 years of age. In our study, sonography showed the CVI in 18 (21%) of 87 infants. Unlike the cavum septi pellucidi and cavum vergae, the CVI has not been linked to neuropsychiatric disorders or dysfunction of the limbic system (6, 7). Hydrocephalus as a result of an arachnoid cyst of the velum interpositum is rare and may sometimes require surgical fenestration of the cyst (8). Distinguishing between an arachnoid cyst and a prominent CVI is difficult without the use of CT cisternography, which is complicated to perform in young infants. The present study shows the capability of color Doppler sonography in delineating the CVI and its neighboring anatomy, as well as its limitation in defining the nature of an enlarged CSF space within the cistern. The size of the CVI in our patients was less than 10 mm, and in none of them was there compression of the foramen of Monro or quadrigeminal plate.

The CVI has frequently been described on axial CT and MR studies (9); it is characteristically triangular in shape with a wide base dorsally that converges anteriorly at the interventricular foramina. With the increased axial resolution of sonography and the capability of color flow mapping, both the CVI and the internal cerebral veins can be seen in real-time mode. It is important to know the normal sonographic appearance of the CVI and its anatomic relationship to the internal cerebral veins in order to avoid misinterpreting the CVI as a pathologic pineal region cyst at routine neonatal cranial sonography.

Conclusion

The CVI is an anatomic variation that may appear as a cyst in the pineal region on neonatal sonograms. Typically, it has an inverted helmet shape and lies beneath the fornices and above the internal cerebral veins.

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