Anatomical variations of *septum pellucidum*

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Abstract Septum Pellucidum is a thin medial septum of triangular shape that consists of two nervous laminae that are attached and located between the corpus callosum and the fornix. Anatomical variations of septum pellucidum appear during fetal life in the ventro-dorsal position. These variations are: cavum septi pellucidi, cavum vergae and cavum veli interpositi. The presence or absence of these cavities can be related to the presence of nervous system or neuropsychiatric dysfunction, therefore they should be well known to avoid wrong diagnoses.

Keywords: Septum pellucidum; Cavum septum pellucidum; Cavum vergae; Cavum velum interpositum

Introduction

During intrauterine life, there are normal midline cavities which usually persist in adulthood and should not be confused with pathological entities. It is important to know them, as they may be related to concomitant neurological or neuropsychological diseases. In this article, we review the *septum pellucidum* (SP) and its anatomical variations. In Latin, the word septum (saepire) means fence or partition wall, while *pellucidum* or perlucidum means translucent. Thus, SP (or *lucidum*) is a thin medial septum of triangular shape that consists of two nervous laminae that are attached and located between the corpus callosum and the fornix (fig. 1)\(^1\)-\(^5\). In 1966, Andy and Stephen called it “telencephalic septum” (*septum telencephali*) 6. Boundaries are described in table 1\(^1\),\(^4\)-\(^6\).

The SP serves as a relay station, containing fibers that connect with hippocampus and the hypothalamus\(^2\). Complete absence of the SP occurs in 2 to 3 individuals per 100 000 people, being a predictor of brain abnormalities, such as: septooptic dysplasia, corpus callosum abnormalities, holoprosencephaly, lissencephaly or Chiari malformation\(^6\),\(^7\).

During intrauterine life, there are three potential cavities in the midline between the lateral ventricles. These cavities regress between the seventh month of fetal life and the second year of postnatal life, but some may persist in adulthood\(^8\),\(^9\). These cavities, first described in the year 1600, include: *cavum septum pellucidum* (CSP), *cavum vergae* (CV) and *cavum veli interpositi* (CVI). They occur with a prevalence of 0.14%\(^8\)-\(^10\).

It is important to highlight that these cavities are in direct contact with the subarachnoid space, but they do not communicate with or are considered part of the ventricular system. As these cavities are not lined with ependyma or choroid plexus cells, they do not produce cerebrospinal fluid (CSF)\(^3\),\(^9\)-\(^11\). 1) *Cavum septum pellucidum*: it is also known as *cavum septi pellucidi*, the ventricle of the septum or fifth ventricle (fig. 2)\(^3\),\(^8\),\(^10\),\(^12\). It can be found in all fetuses at 36 weeks’ gestation and persists in 36% of full-term infants, only 6% of them persist after the sixth month of life\(^3\),\(^4\),\(^11\)-\(^13\). It is significantly more common in women\(^3\).

CSP is part of normal development. As from 12 weeks of gestational age, the corpus callosum starts to develop from the lamina terminalis as a fiber bundle that connects the two hemispheres, also originating the SP. The space between the two laminae that are not fused, located between the frontal horns of the lateral ventricles and anterior to the foramen of Monro is called CSP (fig. 3)\(^10\),\(^11\),\(^14\).

A number of theories have been proposed for the origin of CSP, but it is thought that during embryo-fetal development, the mass of cells occupying the space of the SP is involved in the development of the commissural plate. Selective elimination of this group of cells would lead (by necrosis) to the molecular concentration of large amounts of amino acids, which would attract fluids to achieve a balance in the oncotic pressure of the plate. Fluid pressure would be responsible for
the formation of CSP\textsuperscript{12}. However, it has also been hypothesized that this entity may originate during infancy, as a result of repeated shaking, when rocking infants vigorously in an attempt to soothe them\textsuperscript{12}.

CSP is a triangular space between the two laminae of the septum pellucidum (its boundaries are detailed in Table 2)\textsuperscript{3,4,8,10,12,13,15,16}. CSP may occur in isolation or in association with cavum vergae, communicating with the latter through the aqueductus caudae septi or aqueductus ven-triculii vergae\textsuperscript{7,8}.

CSP is an important marker for the evaluation of normal development of the fetal neural axis. Absence of the CSP is rarely an isolated finding, as nonvisualization of the CSP on ultrasound (US) or magnetic resonance imaging (MRI) scans in fetal life is associated with brain malformations, such as holoprosencephaly, septo-optic dysplasia, agenesis of the corpus callosum, Alexander disease, tuberous sclerosis, phakomatosis, pinealoma, trisomy 21 and schizencephaly\textsuperscript{3,10,12,14,16}.

Considering embryonic development, CSP may not occur without the development of the corpus callosum; therefore agenesis of the corpus callosum is always associated with agenesis of the SP\textsuperscript{3,4}.

There are US studies in which CSP has been identified in 100% of fetuses between 18 and 37 weeks’ gestation, and in 79% of fetuses between 30 and 41 weeks’ gestation; in newborns, complete posterior closure has been seen in 97%, so the CSP is present when the cavum vergae is absent\textsuperscript{16}. Hence, visualization of the CSP between 18 and 20 weeks’ gestation implies normal development of the brain\textsuperscript{16}.

In patients with schizophrenia or in aggressive, alcoholic individuals or people with neurological development disorders, there is a higher prevalence of enlarged CSP\textsuperscript{3-5,11,14,15,17,18}. It was De Greef who first reported an association between CSP and schizophrenia\textsuperscript{11}.

Some authors report an association between boxing and the presence of CSP due to repeated brain trauma. An association between CSP and posttraumatic stress disorders has also been reported, in the military population currently participating in war conflicts or in veterans of wars\textsuperscript{2,3,5,12,13,15,17}.

There are various classifications for CSP. Based on whether the CSP communicates with the lateral ventricles through fenestrations, it may be classified as communicating or non-communicating (more common)\textsuperscript{2,13}. However, another classification focuses on asymptomatic (communicating or non-

### Table 1: Boundaries of the septum pellucidum.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPERIOR</td>
<td>Inferior surface of the body of corpus callosum</td>
</tr>
<tr>
<td>ANTEROINFERIOR</td>
<td>Superior surface of the genu of corpus callosum</td>
</tr>
<tr>
<td>POSTEROINFERIOR</td>
<td>Corpus and columns of the fornix</td>
</tr>
<tr>
<td>LATERAL</td>
<td>Medial wall of frontal horns of lateral ventricles</td>
</tr>
<tr>
<td>MEDIAL</td>
<td>Virtual space with contralateral septum</td>
</tr>
</tbody>
</table>

![Figure 1](image1.png)  
**Figure 1.** Axial T2-weighted magnetic resonance imaging of the brain demonstrating normal appearance of the septum pellucidum (lucidum) (arrow).

![Figure 2](image2.png)  
**Figure 2.** Sketch of axial and sagittal views of the cavum septum pellucidum.
communicating CSP) and symptomatic (non-communicating CSP) characteristics; the latter may be simple, not complicated or complicated by brain injuries.  

2) Cavum vergae: Andrea Verga, an Italian anatomist described it in 1851. It is also known as cavum fornicis, cavum psalterii, Verga's ventricle, the ventricle of Strambio, ventriculus triangularis or sixth ventricle. Cavum vergae is the posterior extension of CSP, extending as far as the posterior columns of the fornix and the foramen of Monro (fig. 4). It is triangular in shape (its boundaries are listed in table 3). Cavum vergae begins to develop by the 5th month of gestation and disappears by two months of age. CV is present in 30% of normal newborns, subsequently regressing and disappearing. The incidence of CV was 2.3% in 1032 brains studied, and it is important to highlight that it is almost always found in association with CSP. When the CSP is dilated, the CV is also dilated, as they join through a defect of the fornix, which is not in contact with the corpus callosum (fig. 5). Some authors report a higher prevalence of enlarged CSP or CV in patients with schizophrenia.

3) Cavum velum interpositum (CVI) was first described by Kruse and Schaeetz in 1930. It is also known as cisterna interventricularis, ventriculus tertii, transverse fissure or sub-trigonal fissure. The incidence of CVI ranges, according to various authors, between 21 and 34%, and persistence in postnatal life is rare, being 30% in 1-10 year-old children, with no significant differences between genders. CVI is a subarachnoid cistern arising as an extension of the cisterna magna and which originates from the roof plate of the diencephalo, protruding into the primitive neural tube approximately during the third fetal month. CVI is a normal

<table>
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<tr>
<td>ANTERIOR</td>
<td>Genu of corpus callosum</td>
</tr>
<tr>
<td>POSTERIOR</td>
<td>Corpus and columns of the fornix</td>
</tr>
<tr>
<td>SUPERIOR</td>
<td>Inferior border of the body of corpus callosum</td>
</tr>
<tr>
<td>INFERIOR</td>
<td>Rostrum of the corpus callosum and anterior white commissure</td>
</tr>
<tr>
<td>LATERAL</td>
<td>Laminae of septum pellucidum</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Boundary</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTERIOR</td>
<td>Crus of the fornix</td>
</tr>
<tr>
<td>POSTERIOR</td>
<td>Body of the corpus callosum</td>
</tr>
<tr>
<td>SUPERIOR</td>
<td>Splenium of the corpus callosum</td>
</tr>
<tr>
<td>INFERIOR</td>
<td>Hippocampal commissure and psalterium (lyra davidis)</td>
</tr>
</tbody>
</table>

Figure 3 Axial T1-weighted magnetic resonance of the brain demonstrating the presence of a triangular cavity between the frontal horns of the lateral ventricles, known as cavum septum pellucidum (arrowhead).  

Figure 4 Sketch of axial and sagittal views of the cavum septum pellucidum associated with the cavum vergae.
cavity in the development of the brain\(^9,10\) (fig. 6) and its presence has not been associated with neuropsychiatric disorders or dysfunction of the limbic system\(^19\).

CVI is a triangular cavity of dorsal base located in the choroidal fissure (fig. 7). The boundaries of CVI are detailed in table 4\(^9,10,13,19,20\).

It is important to distinguish CVI from CV. One of the main features is the fact that CV always coexists with CSP, but these entities can also be differentiated by the location of the internal cerebral veins, as CV lies above these veins, whereas CVI encloses them.

CVI should also be differentiated from an arachnoid cyst of the quadrigeminal cistern or from a pineal cyst. The latter lies inferior to the internal cerebral arteries\(^9,19\).

**Table 4: Boundaries of the cavum velum interpositum.**

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPERIOR</td>
<td>Corpus callosum (lower border) and hippocampal commissure</td>
</tr>
<tr>
<td>INFERIOR</td>
<td>Tela choroidea of the third ventricle and thalamus</td>
</tr>
<tr>
<td>LATERAL</td>
<td>Crus of the fornix</td>
</tr>
<tr>
<td>ANTERIOR</td>
<td>Foramen of Monro</td>
</tr>
<tr>
<td>POSTERIOR</td>
<td>Pineal region</td>
</tr>
<tr>
<td>INFEROLATERAL</td>
<td>Internal cerebral veins</td>
</tr>
</tbody>
</table>

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**Figure 6** Sketch of axial and sagittal view of the cavum velum interpositum.

**Figure 5** Axial T2-weighted magnetic resonance of the brain demonstrating a cavity filled with cerebrospinal fluid and interposed between the lateral ventricles (asterisk). The finding is consistent with cavum septum pellucidum associated with cavum vergae.

**Figure 7** FLAIR axial magnetic resonance imaging of the brain showing a triangular cavity cephalic to the fornix, between the lateral ventricles, called cavum velum interpositum (arrowhead).
Anatomical variations of septum pellucidum

Imaging diagnosis of SP and variants

Prenatal diagnosis is made by transabdominal ultrasound and, in the case of cephalic presentation, transvaginal ultrasound allows better visualization of its variants (fig. 8)10.

The columns of the fornix should be differentiated from a CSP to avoid making mistakes, and the same applies to enlarged CSP in the presence of CV, when the latter laterally displaces the CSP leaflets mimicking an absent CSP14,17.

Differential diagnosis for an enlarged CSP include vein of Galen aneurysm (which is diagnosed by color Doppler technology with knowledge of the anatomy of the region), arachnoid cyst and dilated third ventricle (distinguished by its location between the thalami)14.

In the fetus, CSP and CV can be seen by US and MRI, although the latter may replace US in cases of maternal obesity and oligohydramnios3,5,14,21. MRI has the advantage of delineating the pineal gland with respect to the quadrigeminal cistern or pineal cysts, differentiating such cysts from CVI21.

The anterior extension of the CVI is best displayed on axial T2-weighted MR images, while the posterior extension of the CVI can be seen as an anechoic inverted helmet-like structure on US scans (the convex side of this helmet is formed by the internal cerebral veins). Differential diagnosis is made on the basis of the position of the internal cerebral veins, as arachnoid cysts compress the tectum towards the brain and displace the internal cerebral veins upward against the splenium of the corpus callosum (which differentiates them from the CVI)21.

Figure 8 Coronal fetal ultrasound showing the cavum septum pellucidum (asterisk).

Conclusion

It is important to recognize anatomical variations of the septum pellucidum so that they may not be wrongly diagnosed as interhemispheric cystic lesions, whether before or after birth. Recognition of such variations during fetal life serves as a predictor for the detection of brain malformations or behavior disorders.

Conflicts of interest

The authors declare no conflicts of interest.

References