

## Review Article

# Colloid cysts posterior and anterior to the foramen of Monro: Anatomical features and implications for endoscopic excision

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## Abstract

**Background:** Colloid cysts are usually located at the rostral part of the third ventricle in proximity to the foramina of Monro. Some third ventricular colloid cysts, however, attain large sizes, reach a very high distance above the roof of the third ventricle, and pose some challenges during endoscopic excision. These features led to the speculation that for such a pattern of growth to take place, the points of origin of these cysts should be at areas away from the foramina of Monro at which some anatomical “windows” exist that are devoid of compact, closely apposed forniceal structures.

**Methods:** A review of the literature on anatomical variations of the structures in the vicinity of the roof of the third ventricle and on reported cases with similar features was conducted.

**Results:** Colloid cysts may grow vertically up past the roof of the third ventricle through anatomical windows devoid of the mechanical restraint of the forniceal structures.

**Conclusion:** Some anatomical variations of the forniceal structures may allow unusually large sizes and superior vector of growth of a retro- or post-foraminal colloid cyst. Careful preoperative planning and knowledge of the pertinent pathoanatomy of these cysts before endoscopic excision is very important to avoid complications.

**Key Words:** Cavum, colloid cyst, endoscopic, foramen of Monro, fornix, third ventricle

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## INTRODUCTION

Colloid cysts are usually located at the rostral part of the third ventricle in proximity to the foramina of Monro between the columns of the fornix. Classically, they are attached by a vascular pedicle originating from either the ependyma or the choroid plexus of the third ventricle.<sup>[12]</sup> Colloid cysts usually present clinically when

they are relatively small owing to early obstruction of both the foramina of Monro.<sup>[16,19]</sup>

Notwithstanding, it was our observation that some third ventricular colloid cysts which we treated have attained large sizes and reached a very high distance above the roof of the third ventricle at the time of clinical presentation and diagnosis. Upon endoscopic excision,

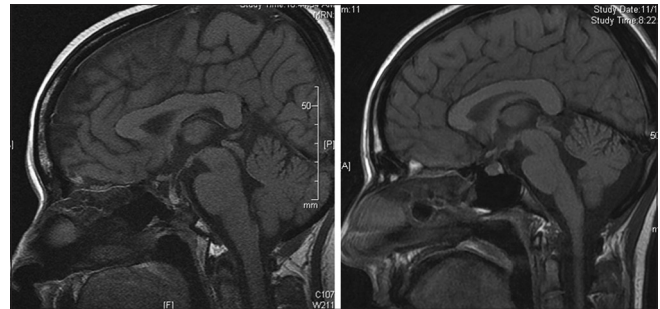
these lesions were noted to bulge into the cavity of the lateral ventricle, obstruct the foramen of Monro, and require opening of the septum pellucidum to be accessed. Such features raised questions regarding the pathological anatomy and point of origin in this subcategory of colloid cysts because if they have originated in the classic location, they should have led to cerebrospinal fluid (CSF) flow obstruction and consequent clinical symptoms at an earlier stage of their growth. Moreover, for a slowly growing lesion like a colloid cyst that takes origin within the cavity of the third ventricle near the foramina of Monro where a mechanical restriction by the two columns of the fornix exists, it is logical to predict an inferior direction of growth toward the area of least resistance into the ventricular cavity, contrary to what is noted in large colloid cysts which grow so far superiorly above the third ventricle's roof. As a matter of fact, the magnetic resonance imaging (MRI) of large colloid cysts usually reveals that almost the whole extent of the third ventricular roof is occupied by the cyst, making it very difficult to precisely determine its point of origin. Based upon the aforementioned reasoning, we speculated that the points of origin of these cysts should be at areas away from the foramina of Monro and at which some anatomical "windows" exist that are devoid of compact, closely apposed forniceal structures. To further elucidate these points, we conducted a review of the literature on the anatomical variations of the structures in the vicinity of the roof of the third ventricle as well as the reported cases displaying similar features.

## ANATOMY AND VARIATIONS OF THE FORNIX

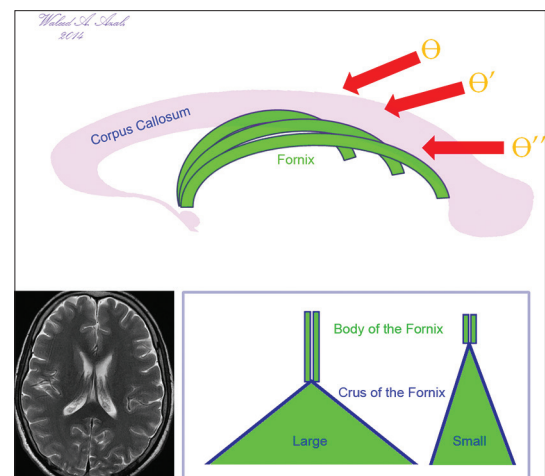
As the crura of the fornix from both sides wrap around the posterior surface of the pulvinar of the thalamus, they arch superomedially underneath the splenium of the corpus callosum heading toward the midline. At this point, a small number of fibers cross the midline to join the contralateral fornix forming the fornical (hippocampal) commissure or psalterium.<sup>[10,24]</sup> MRI studies demonstrate marked variation of the point on sagittal plane at which the fornix diverges from the inferior surface of the corpus callosum and at which the septum pellucidum appears.<sup>[8,21,22,31]</sup> Such variation would entail that the lengths of the bilateral forniceal crura and the angles at which they meet to form the body of the fornix are variable among subjects [Figures 1 and 2]. Consequently, the dimensions of the triangular area of the roof of third ventricle bordered by the two forniceal crura and devoid of midline compact neural structures would be larger in some patients, allowing a posteriorly originating colloid cyst to enlarge superiorly above the level of the roof of the third ventricle [Figure 3].

Classically, the two fornices are described to merge forming the body of the fornix, but evidence from MRI

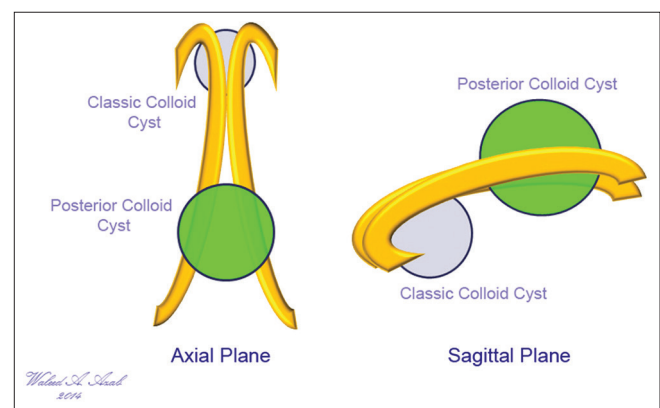
indicates that they join but always maintain an obvious, separate identity.<sup>[10]</sup> The body of the fornix runs anteriorly in the free inferior edge of the septum pellucidum



**Figure 1: Sagittal MR images demonstrating variable points of forniceal "take off" from the undersurface of the corpus callosum**



**Figure 2: Illustration of the variations of the lengths of the forniceal crura and their angles  $[\theta]$  of divergence from the undersurface of the corpus callosum with consequent variable dimensions of the triangular area posterior to the body of the fornix [inset]. The axial T2-weighted MR image at the level of the two forniceal bodies demonstrates this triangular area (compare to the inset)**



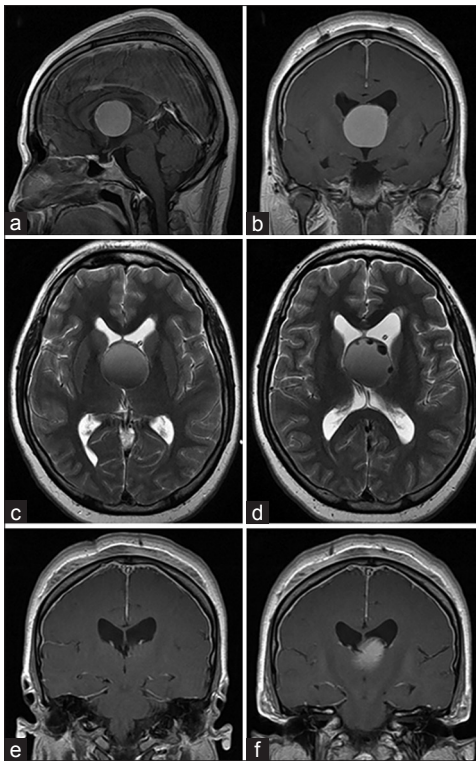
**Figure 3: Illustration in axial and sagittal planes of the superiorly directed vector of growth of a colloid cyst originating posterior to the foramen of Monro compared to a cyst originating in a classic location. The window between the two crura of the fornix is devoid of anatomical restraints and allows a larger size and enlargement beyond the ventricular roof**

between the roof of the third ventricle and the floor of the bodies of the lateral ventricles.<sup>[10,24]</sup> The potential separability of the forniceal structures is supported by experience from microsurgical transcallosal interforaminal approaches to the third ventricular lesions.<sup>[1,2,25]</sup> Furthermore, Vialogo reported a case of colloid cyst of the third ventricle located at a retroforaminal position on the diencephalic roof. Although the cyst was found inside the cavum of the septum pellucidum and protruded on the floor of lateral ventricles, the author described the lesion to have dissected the raphe fornix, split the two fornices apart, and expanded superoposteriorly. The cyst was approached via an endoscopic transepto-interforaminal approach between the two fornices. In his report, the author provided intraoperative endoscopic images of the two fornices pushed apart by the tumor.<sup>[29]</sup> In another case of cavum septum pellucidum colloid cyst reported by Timurkaynak *et al.*, although it is clear from the MR images provided by the authors that the cyst was not very large, they describe the microsurgical findings of an interforaminal raphe that was transformed into a thin layer by tumor pressure and location of the most part of the cyst posterior to the foramen of Monro.<sup>[27]</sup> In one case of

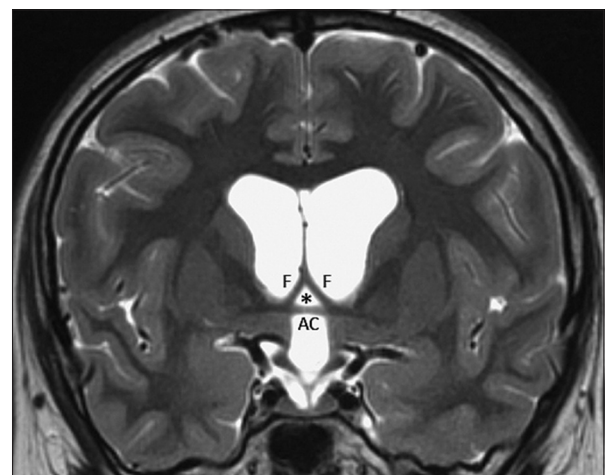
a relatively large colloid cyst that we treated [Figure 4], the cyst was almost reaching the inferior surface of the corpus callosum with no cavum septae pellucidi or vergae noted. These neuroradiological findings would support a retroforaminal origin of the cyst that has grown up between the fornices, even though no cavum septae pellucidi [CSP] or vergae existed.

The choroid plexus from each lateral ventricle extends through the foramen of Monro and is continuous with the two parallel strands of choroid plexus in the roof of the third ventricle. In the atrium, the choroid plexus forms a prominent triangular tuft called the glomus. The thalamus and fornix bordering the choroidal fissure have small ridges, called the teniae, along which the tela choroidea is attached. The tenia on the thalamic side is called the tenia thalami or tenia choroidea and the tenia on the forniceal side of the fissure is called the tenia fornix.<sup>[24]</sup> There are no documented cases of colloid cysts growing through the choroid fissure. This suggests that both the tenia fornices and thalami represent a restriction to a colloid cyst's superior direction of growth which rather takes place in between and not lateral to the two forniceal crura.

The fornices separate again at a variable point in the vicinity of the rostral thalamus to form the two anterior columns of the fornix.<sup>[10]</sup> The columns then arch along the superior and anterior margins of the foramen of Monro in their course toward the mamillary bodies.<sup>[24]</sup> The foramina of Monro are the highest points in the anterior wall of the third ventricle and are located at the junction of the roof and the anterior wall of the third ventricle. At the next lower level in the anterior wall of the third ventricle, the anterior commissure transversely crosses the midline between the rostrum of the corpus callosum anteriorly and the columns of the fornix



**Figure 4:** One of our cases with large colloid cyst. Sagittal (a) and coronal (b) T1-weighted MR images with contrast demonstrate the cyst to reach the inferior surface of the corpus callosum. Axial T2-weighted MR images at two consecutive cuts (c, d) demonstrating the flattened forniceal columns. Coronal T1-weighted MR image with contrast (e) demonstrates the normal internal cerebral veins at the posterior third ventricular roof becoming splayed by the lesion in the next anterior cut (f). No cavum septae pellucidi or vergae are present



**Figure 5:** Coronal T2-weighted MR image from a patient with pineal region tumor and triventricular hydrocephalus. Note the anterosuperior triangular window (asterisk) between the anterior commissure and the columns of the fornix

posteriorly [Figure 5]. The distance from the posterior edge of the anterior commissure to the anterior border of the foramen of Monro ranges from 1.0 to 3.5 mm. The upper third of the anterior wall of the third ventricle lies posterior to the rostrum of the corpus callosum which receives the attachment of the lower border of the septum pellucidum.<sup>[24]</sup>

The junction of the roof of the third ventricle, upper third of its anterior wall, and the septum pellucidum, in addition to the variation of the point at which the two columns of the fornix diverge are of importance to comprehend how a colloid cyst originating anterior to the foramen of Monro finds its way above the foraminal level between the leaflets of the septum pellucidum. When the point of forniceal divergence is relatively posterior, the triangular area bordered by the columns of the fornix bilaterally and the anterior commissure anteroinferiorly would consequently be larger permitting the cyst to enlarge in a superior direction [Figure 6]. Koç *et al.* reported one case of colloid cyst located within a cavum septi pellucidi in which inspection of the MR images revealed that the cyst was actually anterior to the foramen of Monro and occupied the cavum between the two frontal horns of the lateral ventricles.<sup>[15]</sup>

An important anatomical feature that should be taken into consideration is that the fornical columns have a pre-commissural and post-commissural component around the anterior commissure, which may be of importance in restricting anterior cystic extension as to any angle or increase the distance between the columns.

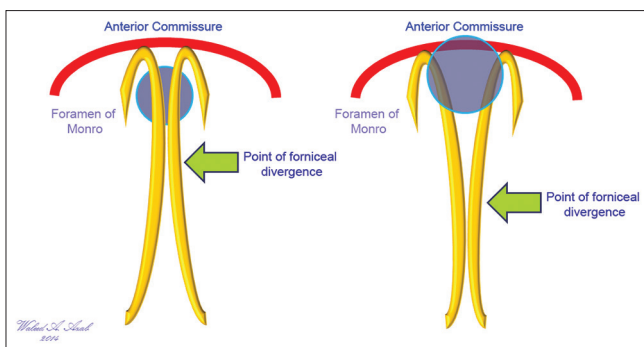
## ANATOMY AND VARIATIONS OF THE SEPTUM PELLUCIDUM

During early fetal development, the continuous growth of the cerebral hemispheres causes the massa commissuralis to expand rapidly arching over the thin

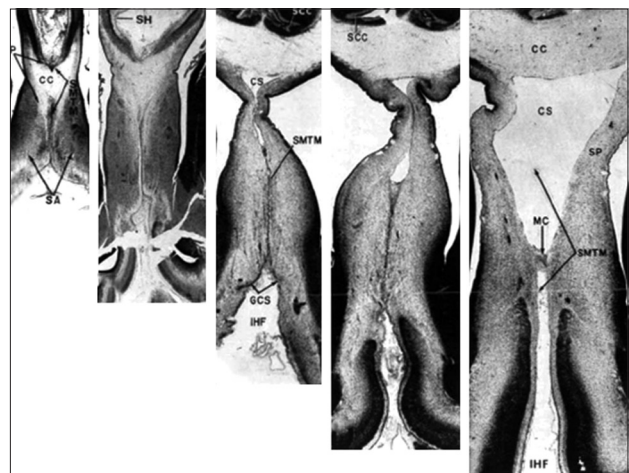
roof of the diencephalon within the interhemispheric cleft. The massa commissuralis lies superior to the fornix which also infolds in the midline along with the hippocampal primordium. The massa commissuralis grows caudally more rapidly than the fornix, and so the splenium of the corpus callosum eventually overrides the fornix. As the rostrum of the corpus callosum develops, it closes off the residual sulcus medianus telencephali medii groove from the inter-hemispheric fissure forming the CSP as a closed pocket lying between the corpus callosum and the fornix. The lateral walls of the CSP are formed from the lamina reuniens. The walls are initially thick, but with rapid growth of the cerebral hemispheres, corpus callosum, and fornix, the walls become thin. As a result of that process, the CSP elongates and widens [Figure 7].<sup>[10]</sup>

The anatomy of the fornix and the septum pellucidum are indeed closely related. Embryologically, the septum pellucidum is a band of tissue that extends below the corpus callosum to join the fornix.<sup>[23]</sup> It is usually 1-3 mm thick and consists of two fused laminae that were separate during fetal life.<sup>[10]</sup> The cavity between the two leaves or cavum septi pellucidi is a well-known normal finding in fetal ultrasound.<sup>[5]</sup> The bilateral vertical laminae of the septum pellucidum are attached to the concave surfaces of the body, genu, and rostrum of the corpus callosum and occupy the interval between these structures and the fornix.<sup>[17]</sup>

Postnatally, a narrow or a potential cavity exists between the two leaves of the septum pellucidum.<sup>[10]</sup> Notwithstanding, the reported incidence of cavum septi pellucidi varies widely between studies and ranges from 2 to 85%.<sup>[7,13,20]</sup> When a cavum septi pellucidi persists, it is bounded posteriorly by the columns of the fornix and inferiorly by the anterior commissure and the rostrum of the corpus callosum.<sup>[3]</sup> On the other hand, a cavum



**Figure 6: Illustration of the variation of the point of diverging fornical columns and consequent formation of a larger anterosuperior window in the roof of the third ventricle which creates a route for superior direction of growth of colloid cysts originating anterior to the foramen of Monro**



**Figure 7: Serial photographs demonstrating the development of the septum pellucidum in human embryos. From Rakic and Yakovlev (1968)<sup>[23]</sup> with permission**

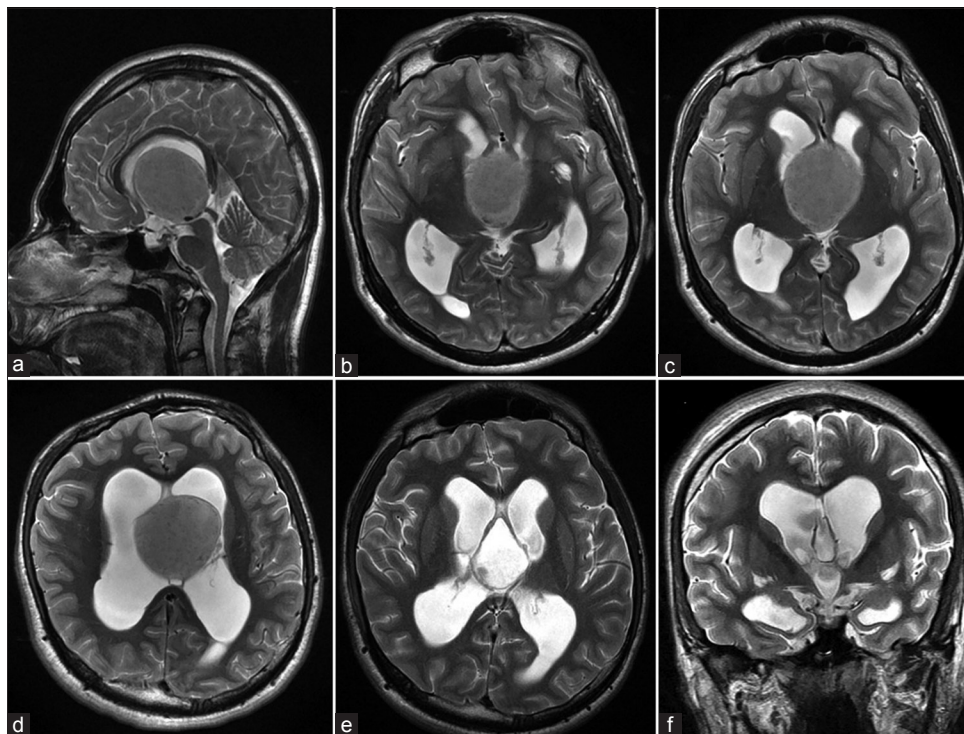
vergae is a posterior extension of a cavum septi pellucidi past the columns of the fornix and the foramina of Monro in which the separation of the leaflets of the septum pellucidum continues backward up to the splenium of the corpus callosum.<sup>[28]</sup> In a relatively recent MRI study of 151 healthy volunteers, Born *et al.* reported an incidence of cavum septi pellucidi, including all sizes, of 72% and an enlarged cavum in 9% with no dependency on age or gender. The incidence of cavum vergae was 33%, out of which 29% was associated with cavum septi pellucidi.<sup>[3]</sup>

Colloid cysts of the septum pellucidum have infrequently been reported.<sup>[6,15,26,27,29]</sup> Ciric and Zivin reported two cases of colloid cysts that originated superior to the diencephalic roof, occupied the space between the two fornices, and separated the two leaflets of the posterior part of the septum pellucidum. The cysts were firmly attached to the superior surface of the velum interpositum and both internal cerebral veins, and were exposed through a microsurgical right transfrontal transventricular approach. The authors pointed out that despite the fact that the two fornices and the two leaves of the septum pellucidum usually adhere, the microsurgical dissection of autopsy specimens has shown that they may remain separated. Such findings may explain how a lesion with an origin in the diencephalic roof may present both within the third ventricle as well as above it between the two fornices and the two leaves of the septum pellucidum.<sup>[6]</sup> During endoscopic

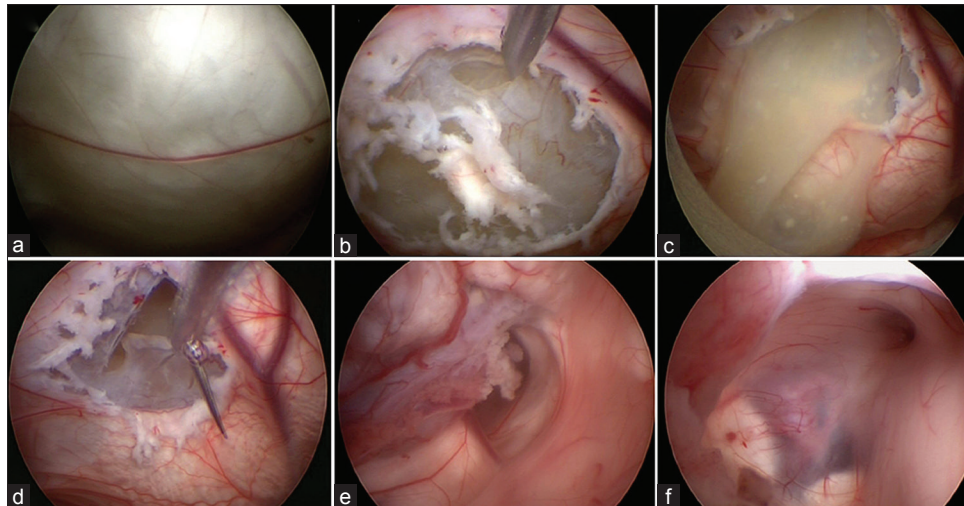
transcavum interforneal endoscopic surgery of the third ventricle, the persistence of the cavum septi pellucidi renders the fornices sufficiently separated to allow safe entry of the endoscopic instruments along the whole length of the cavum.<sup>[26]</sup> The presence of a cavum septi pellucidi or its posterior extension with concomitant separation of the fornices eliminates the midline mechanical restraint above a growing colloid cyst that subsequently enlarges superiorly between the two leaflets of the septum pellucidum. This is exemplified by the MR images of one of our cases [Figure 8]. In such cases, a window through one septal leaflet always needs to be created to gain access to the cyst wall for further manipulation and excision. Careful choice of the area at which the septum is opened is important so as to avoid an injury to the fornix [Figure 9]. It should be noted that this is clearly a different surgical technique from endoscopic excision of classic colloid cysts which is performed via a transforaminal route without opening the septum pellucidum [Figure 10].

## ANATOMY AND VARIATIONS OF THE VELUM INTERPOSITUM

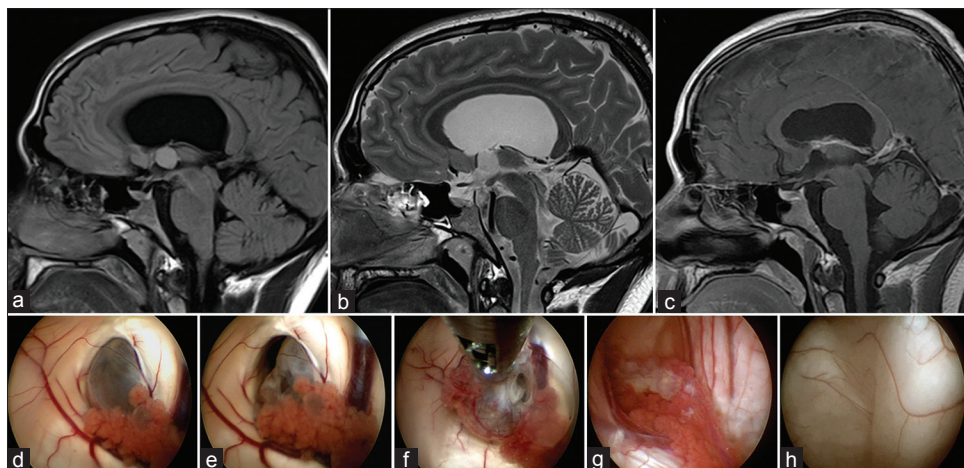
The velum interpositum is the potential space between the dorsal and ventral layers of tela choroidea which encloses the internal cerebral veins and medial posterior choroidal arteries. The velum interpositum, the two layers of tela



**Figure 8:** Preoperative (a-d) and postoperative (e, f) T2-weighted MR images of one case from our records. Note the very large size of the colloid cyst reaching the corpus callosum and the splayed fornices in (b) and (c) axial images. Evidence of cavum septae pellucidi and vergae is seen in the preoperative axial cut (d) anterior and posterior to the cyst wall. The presence of cavum septae pellucidi and vergae is seen clearly in both axial (e) and coronal (f) postoperative images



**Figure 9:** Intraoperative images during endoscopic excision of the colloid cyst in Figure 6. (a) Initial endoscopic view within the lateral ventricle reveals a bulging septum pellucidum. (b) Opening the septum pellucidum leaflet exposes the cyst wall and content aspiration is started. (c) Cyst contents coming through the opening of the cyst wall. Note the calcium flakes which are commonly seen in large colloid cysts. (d) Further expansion of the cyst wall opening. (e) The foramen of Monro is seen after the cyst was decompressed and excised. (f) View of the floor of the third ventricle at the conclusion of the operation (courtesy of Professor Dr. Henry W. S. Schroeder)



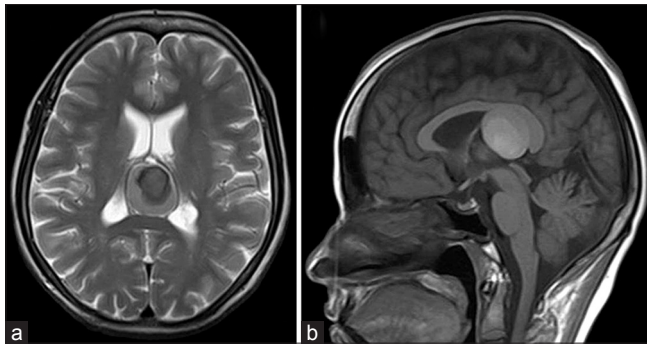
**Figure 10:** Classic colloid cyst at the foramen of Monro. Preoperative T2-FLAIR (a) and T2-weighted (b) sagittal MR images. Postoperative sagittal T1-weighted image with contrast after total excision (c). Intraoperative sequential images of endoscopic excision through a transforaminal route (d-h)

choroidea, and the body and crura of the fornix form the roof of the third ventricle. The term velum interpositum is often broadened to include the two layers of tela choroidea together with velum interpositum proper.<sup>[18]</sup> Within the velum interpositum, the two layers of tela choroidea have always been described to be interconnected by loosely organized or dense trabeculae.<sup>[24,30]</sup> Zhang *et al.* have recently demonstrated the extension of arachnoid membrane within the whole length of velum interpositum. Two arachnoid layers are lying between the superior and inferior tela choroidea from the habenular commissure to the foramen of Monro.<sup>[32]</sup>

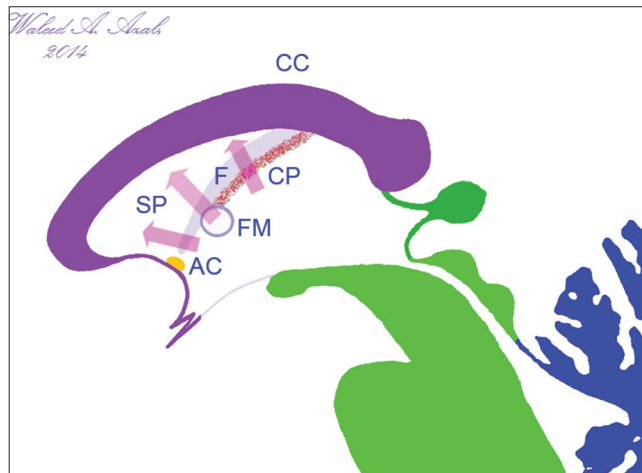
The observation that some colloid cysts develop above and are covered inferiorly by the velum interpositum has been made in the old literature.<sup>[4,6,9,11,14]</sup> Reported

cases of colloid cysts originating within the confines of the velum interpositum are extremely rare.<sup>[12,19]</sup> Hingawala and colleagues reported one case of a colloid cyst that measured about 3 cm in maximal diameter and splayed the two fornices. The cyst was attached to a vascular pedicle arising from the choroid plexus and had flimsy adhesions to both the internal cerebral veins [Figure 11].<sup>[12]</sup> The relation of the internal cerebral veins [ICV] to the cyst wall may, therefore, offer a clue as to whether a colloid cyst originates superior or inferior to the internal cerebral veins. Such information is crucial to predict areas of potential vascular injury during endoscopic excision.

In Figure 12, a collective illustration of the areas of potential restriction and voids for extension of



**Figure 11:** Axial T2-weighted (a) and non-contrast sagittal T1-weighted MR images of the case of velum interpositum colloid cyst reported by Hingwala *et al.* (2009).<sup>[12]</sup> Reprinted with permission



**Figure 12:** An illustration of the areas of potential restriction and voids for extension of a colloid cyst is presented. Pink arrows are representative of areas of growth extension of the cyst above the third ventricular roof

a colloid cyst is demonstrated. It is important to note that in the literature, there are no known differentiating histochemical or growth factor differences between colloid cysts “anterior” or “posterior” to the foramen of Monro. Future studies to analyze these differences may help us understand the tendencies of colloid cyst recurrence and residual growth postoperatively.

## CONCLUSION

Colloid cysts originating away from the foramina of Monro may extend superiorly beyond the diencephalic roof and may be of larger diameters than classic colloid cysts. They grow vertically up through anatomical windows devoid of the mechanical restraint of the forniceal structures. Cavum septae pellucidi and vergae, when present, result in separation of the forniceal structures and allow a superior vector of growth of a retro- or post-foraminal colloid cyst. Careful preoperative planning and knowledge of the pertinent pathoanatomy of these cysts before endoscopic excision is very important to avoid complications.

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