OPEN AIMJ ORIGINAL ARTICLE

Neurosurgery

Neuroendoscopic Unrestricted Access to and Visualization of The Important Anatomical Structures at The Third Ventricle: Surgical Implications and Image Record

Alhusain Nagm [1,*] MD., Ahmed Saleh[1] MD. and Ahmed Salem[1] MD.

** Corresponding Author:*
Alhusain Nagm
nagm@azhar.edu.eg

Received *for publication May 12, 2022;* ***Accepted*** *October 25, 2022;* ***Published online*** *October 25, 2022.*

Citation: *Alhusain N., Ahmed S. and Ahmed S. Neuroendoscopic Unrestricted Access to and Visualization of The Important Anatomical Structures at The Third Ventricle: Surgical Implications and Image Record. AIMJ. 2022; Vol.3-Issue 10 : 168-173.*

doi: 10.21608/aimj.2022.138108.1944

[1]*Department of Neurosurgery, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.*

ABSTRACT

Background: Neuroendoscopic procedures have shown great success as being minimally invasive surgery, which can deal with a lot of intra- and peri-ventricular pathologies. (1) Herein we were to describe the precise topographical relations of specific lesions to individual anatomic variations of intraventricular structures. Aim of the study: studying the accessibility and maneuverability of each recorded anatomical target through visualization and interpretation of neuroendoscopic video-captured images.

Patients and Methods: Consecutive surgical series of one-year duration conducted at Al-Azhar University Hospitals. Out of our series which reached 64 endoscopic cases, we selected cases that showed interesting anatomical variations. In our research, we included 13 Patients who are candidates for neuroendoscopic surgeries of ages ranging from 6 months to 39 years and fulfilled our criteria. Herein, in this paper, we included a sample of 2 cases.

Result: Images description and labeling of important anatomical structures around the 3rd ventricle. Besides, we were able to analyze variable anatomy of the floor of the 3rd ventricle & Liljenquist membrane that increase the surgical challenge and affect the outcome.

Conclusion: Our study was able to participate in achieving safer surgical freedom through understanding the critical landmarks, besides, studying the accessibility and maneuverability of each target. It can help novice neurosurgeons to be ready and well prepared for several surgical challenges based on better anatomical understanding, necessary instrumentation, and skills

Keywords: *Neuroendoscopy; Neuroanatomy; ETV.*

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*
Authorship: *All authors have a substantial contribution to the article.*

INTRODUCTION

Neuroendoscopic surgery has become used on a wide range for treatment of many different pathologies as endoscopic third ventriculostomy for obstructive hydrocephalus, biopsy and tumor resection for intraventricular tumors, cystoventriculostomy for arachnoid cysts.[(1)] Understanding the critical landmarks is very important to achieve successful neuroendoscopy. Besides, studying the accessibility and maneuverability for each target might necessitate modification of the current techniques in order to achieve "Safer surgical freedom".

***Neuroendoscopic Anatomy:**

Lateral ventricle (LV):
Through the coronal approach, the first part to face after entering the ventricular system is the central part of the LV near the frontal horn.[(2)] LV consists of body, atrium and 3 horns; frontal, occipital and temporal. Regarding frontal horn, septum pellucidum forms the medial relation, while the caudate nucleus forms the lateral one. Corpus callosum forms the superior, inferior, and anterior boundaries. Frontal horn of LV is deprived of choroid plexus.[(2,3,4,5)] Moving to the body of the LV, septum pellucidum and body of the fornix are considered the medial margin, while the body of caudate nucleus is the lateral margin. The superior structure is the trunk of corpus callosum, while the inferior one is the thalamus.[(2,3,4,5)] About the atrium and occipital horn, their upper surface is formed by corpus callosum while the lower one is formed by collateral trigone. Their medial side consists of splenium of corpus callosum and calcar avis. Caudate nucleus and tapetum form the lateral margin of the atrium while the tapetum forms the lateral one of the occipital horn.[(2,3,4,5)] Next issue is the temporal horn, which is bounded superiorly by the thalamus, tail of caudate nucleus, and tapetum, inferiorly by collateral eminence and hippocampus, laterally by tapetum, and medially by choroidal fissure.[(2,3,4,5)] Choroid

plexus is settled at the floor of the LV, along with the thalamostriate and septal veins.[6]

- **Foramen of monro (FoM):**

FoM conncets the LVs with the 3rd ventricle. Choroid plexus, thalamostriate, septal, and superior choroidal veins, and the distal branches of the medial posterior choroidal arteries pass through FoM.[6]

- **Third Ventricle:**

The 3rd ventricle is a fissure-like space, bounded laterally by the thalamus and hypothalamus with the hypothalamic sulcus in between.[7] Interthalamic adhesions connect the lateral walls.[7] The anterior boundaries are from superior to inferior; columns of the fornix, FoM, anterior commissure, lamina terminalis, optic recess and lastly optic chiasm[3]. The upper margin is formed by tela choroidea, choroid plexus, along with the velum interpositum[8]. The lower margin consists from anterior to posterior of the optic chiasma and recess, infundibular recess, tuber cinereum, mamillary bodies, Then the posterior perforated substance and the tegmentum of midbrain and finally the cerebral aqueduct.[4] The posterior relations are the posterior commissure, pineal recess and the habenular commissure.[9]

- **Velum Interpositum (VI):**

The VI is a space located between the two layers of the tela choroidea in the 3rd ventricular roof.[10] Tela choroidea is attached through its upper layer to the fornix and through its lower layer to stria medullaris thalami anteriorly and the pineal body posteriorly.[10]

- **Liliequist Membrane (LM):**

LM is an arachnoid sheet present in the interpeduncular and prepontine cisterns, extending from the upper border of the dorsum sellae to the mamillary bodies and pontomesencephalic junction.[11] It has 3 leaves; diencephalic, mesencephalic, and sellar leaves.[12,13]

*** Surgical techniques:**

Endoscopic third-ventriculostomy (ETV): Diversion of the CSF passage to pour in the subarachnoid space.[10] Regarding the technique, the 3rd ventricular floor and LM are opened to make the targeted passage.[10]

ILLUSTRATIVE CASES

Case 1

A 14-year-old male patient presented with Headache, irritability, nervousness and decreased visual acuity. By examination, there is no sensory or motor affection. Visual acuity is 6/6 by glasses. Patient was diagnosed with obstructive hydrocephalus.

Operation: (ETV) (figs. 1,2,3,4,5)

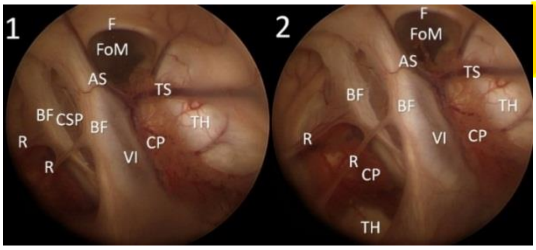

Fig. 1: Case 1: Neuroendoscopic video-captured image shows the major anatomical landmarks: the choroid plexus (CP) passing through (FoM) to the 3rd ventricle. Thalamostriate (TS) and anterior septal (AS) veins joined at its lower end. In these images we can see a normal variation which is cavum septum pellucidum (CSP) as well as the remnants of the septum pellucidum (R). Though this defect we can appreciate the choroid plexus of the opposite left lateral ventricle. The body of fornix (BF) is seen along with its columns (F) at the anterior margin of FoM and below It the velum interpositum (VI). Posterolateral to FoM, thalamus (TH) is present.[14] **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

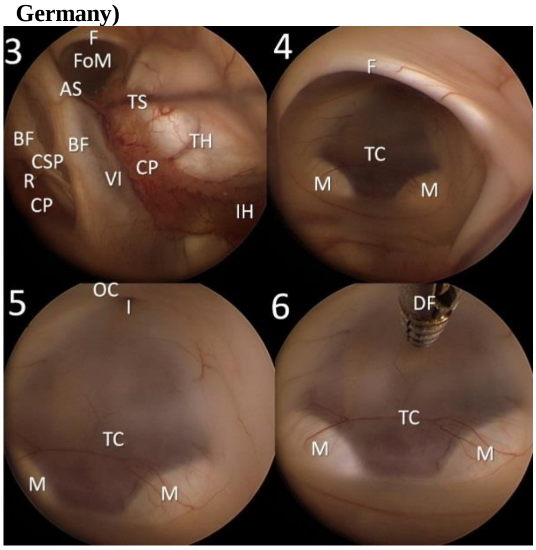

Fig. 2: Case 1: Neuroendoscopic video-captured images: (3) In addition to the anatomical landmarks and cavum septum pellucidum as mentioned before, we can appreciate the entrance of the inferior horn (IH) of the right lateral ventricle. (4) is taken from the right lateral ventricle through the FoM showing the column of fornix (F) and the opaque floor of the 3rd ventricle. (5) Here we can see the separated mamillary bodies (M), tuber cinereum (TC), infundibulum (I) of the pituitary gland and in front of it the optic chiasm (OC). (6) Dick forceps is being introduced to make the ETV stoma at the tuber cinereum. [14] **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

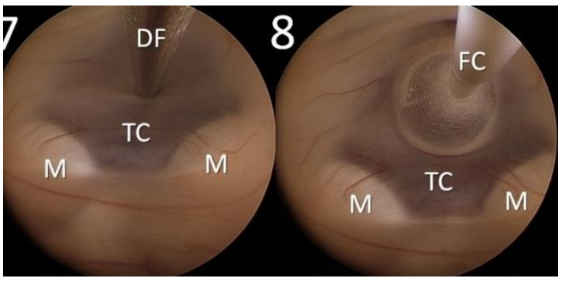

Fig. 3: Case 1: Neuroendoscopic video-captured images: (7) Dick forceps is penetrating the tuber

cinereum (TC). (8) Fogarty catheter (5Fr size) dilates the stoma of ETV. (14) **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

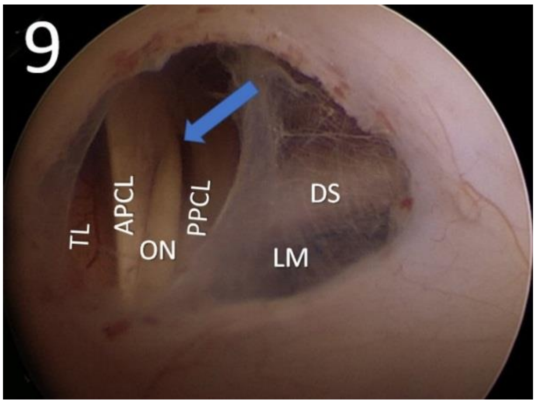

Fig. 4: Case 1: Neuroendoscopic video-captured image shows the dilated ETV stoma. We can see the delicate liliequist membrane (LM), Oculomotor nerve (ON) piercing the porus oculomotaris (blue arrow) between the anterior pertoclinoid ligament (APCL), and the posterior petroclinoid ligament (PPCL). Dorsum sella (DS) and temporal lobe (TL) can be appreciated.(14) **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

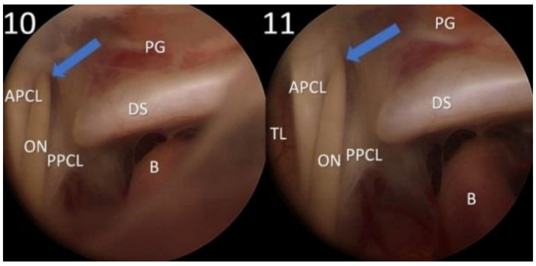

Figure (5): Case 1: Neuroendoscopic video-captured images taken from the ETV stoma showing the basilar artery (B), Dorsum Sella (DS) which is the uppermost part of the clivus with its anterior relation; Pituitary gland (PG), Oculomotor nerve (ON) entering porus occulomotaris (blue arrow) between the 2 folds of Petroclinoid ligament; anterior petroclinoid ligament (APCL), posterior petroclinoid ligament (PPCL). Temporal lobe (TL) can be appreciated. (14) **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

Case 2

A 20-year-old female patient presented with Headache, irritability, nervousness. MRI shows aqueductal stenosis.

Operation: (Endoscopic Third Ventriculostomy) (figs. 6,7,8,9,10)

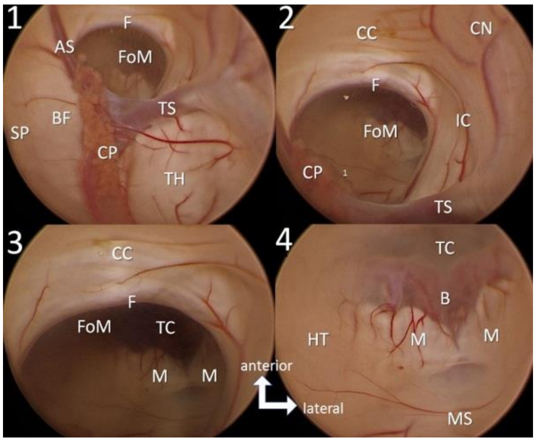

Fig. 6: Case 2: Neuroendoscopic video-captured images, right side approach: (1,2) The choroid plexus (CP) passing through Foramen of Monro (FoM). Thalamostriate (TS) and anterior septal (AS) veins joined at its lower end. Columns of fornix (F) form the anterior margin of FoM. Corpus callosum (CC) is located anterior to columns of the fornix. Anterolateral to FoM, we can appreciate the caudate Nucleus (CN), internal capsule (IC). Posterolateral to FoM, thalamus (TH) is present. Septum Pellucidum (SP) and Body of the fornix form the medial and posteromedial relation to FoM. (3,4) By looking at the floor of the 3rd ventricle, we can distinguish the two mamillary bodies (M) which are connected. They separate the middle segment (MS) posteriorly from tuber cinereum (TC) anteriorly. Here we can notice the floor is very thin and transparent, so that, the basilar apex and bifurcation (B) can be seen easily. Hypothalamus (HT) is seen at the inferior part of lateral 3rd ventricular wall. (14) **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

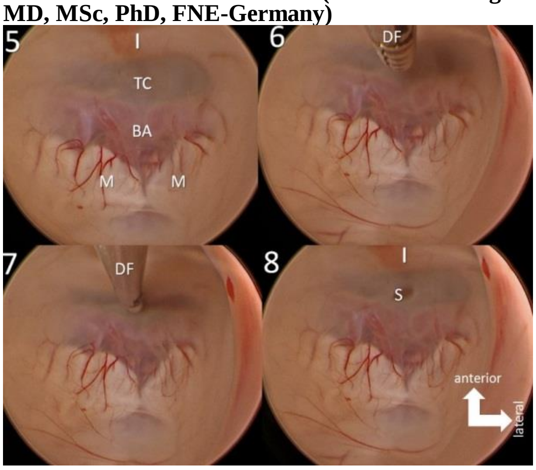

Fig. 7: Case 2: Neuroendoscopic video-captured images: (5) shows the floor of the 3rd ventricle with the 2 mamillary bodies (M) and basilar artery bifurcation (BA) in front of them. Tuber cinereum (TC) is located anteriorly. (6,7) Dick forceps (DF) is making the stoma at the tuber cinereum and infront of the basilar artery. (8) here we can see the stoma (S) of ETV. Notice the orange color of the infundibulum (I). (14) **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

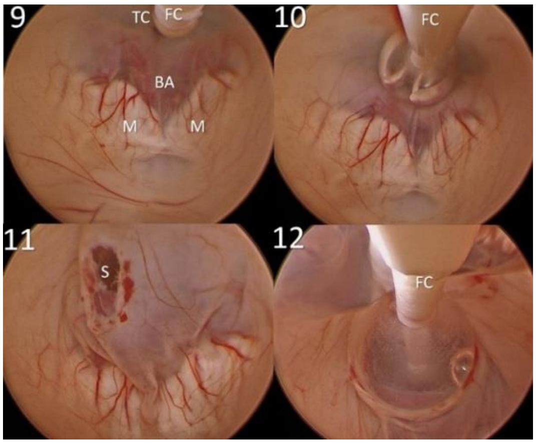

Figure (8): Case 2: Neuroendoscopic video-captured images showing stepwise dilatation of the stoma using fogarty catheter. [14] **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

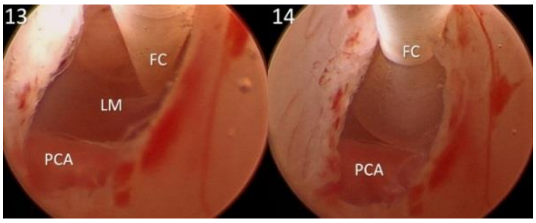

Fig. 9: Case 2: Neuroendoscopic video-captured images show dilatation of liliequist membrane (LM), which appears very thin and delicate here, using fogarty catheter (5fr size). Here also we can see Basilar artery apex and its branch posterior cerebral artery (PCA). [14] **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

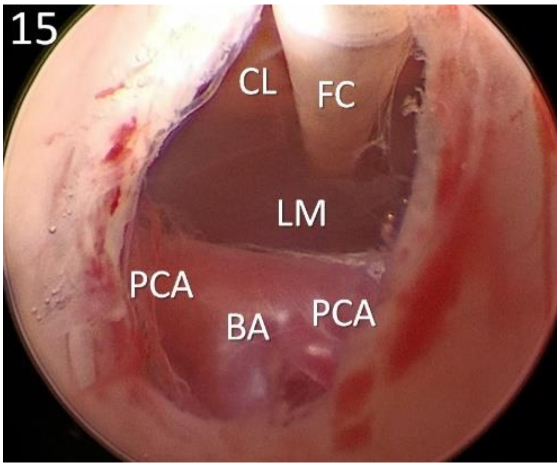

Fig. 10: Case 2: Neuroendoscopic video-captured image shows the bifurcation of basilar artery (BA) to its terminal branches; right and left posterior cerebral arteries (PCA). Anteriorly, fogarty catheter (FC) is dilating liliequist membrane (LM). Clivus (CL) is seen.[14] **(©: Alhusain Nagm MD, MSc, PhD, FNE-Germany)**

RESULTS

In our included illustrative cases, we were able to detect the anatomical structures around the 3^{rd} ventricle. Foramen of monro (FoM) was seen in 12 cases with its variations, we distinguished the small, wide, rotated types besides the dilated one because of a 3^{rd} ventricular lesion filling it. FoM was of average size in 5 cases (42%), narrow in 3 cases (25%), wide and rotated in 4 cases (33%).

We were able to see the anatomical landmarks around the FoM; Thalamus, internal capsule, and caudate nucleus, choroid plexus were seen in 12 cases (all cases of ETV and tumor biopsies). choroid plexus shows 2 variations as it was thick in 4 cases (29%) and thin in 8 cases (71%).

Anterior septal and thalamostriate veins were seen in 12 cases, which were thin in 7 cases, thick and engorged in 5 cases, as well as, corpus callosum, body and columns of the fornix. Septum pellucidum (SP) was detected in 9 cases (69%), absent in 3 cases (25%). Out of these 3 cases, velum interpositum was seen in 2 cases. Septostomy was indicated and done in 2 cases (15%). During septostomy, Cavum septum pellucidum was seen in one case. The frontal horn and atrium of the lateral ventricle were seen in 12 cases (92%), Temporal horn in 4 cases (31%) with the choroid plexus going through it, Occipital horn in (8%). In 10 cases, we were able to see 3rd ventricular floor from the lateral ventricle through FoM. Going through FoM, we were able to see the 3rd venticular floor obviously. Optic chiasm was the most anterior part seen, the infundibular recess which is located anterior to tuber cinereum. Both were seen in 5 cases (38%). The 3^{rd} ventricular floor was described in each of the 10 case with its variations. Out of these 10 cases, it was thin in 6 cases (60%), thick in 4 cases (40%). Also, it shows opacity in 6 cases (60%), transparency in 4 cases (40%). One of these cases, the transparent floor was very congested.

Mamillary bodies were seen in all cases of ETV (10 cases) (77%), with its 2 types separated and connected. Separated mamillary bodies were 5 cases (50%), while connected ones were 5 cases (50%).

We were also able to view the middle segment of the 3rd ventricular floor in 10 cases (77%), interthalamic adhesions (massa intermedia) in one case (8%), cerebral aqueduct, posterior commissure, pineal recess, habenular commissure and roof of the 3^{rd} ventricle were detected in 4 cases (31%). After penetrating the 3rd ventricular floor, we appreciated the liliequist membrane (LM) in 10 cases which was thin in 8 cases (80%) and thick in 2 cases (20%) (fig. 23). Thick LM was opened using scissors, bipolar coagulation electrode, and fogarty catheter.

Basilar artery was seen in all cases of ETV (10 cases) (77%), Clivus in 6 cases (46%), Dorsum sella and pituitary gland in 4 cases (31%). Oculomotor nerve was detected in 3 cases (23%), in 2 of these 3 cases, we were able to see porus occulomotaris, besides, the anterior and posterior petroclinoid ligament. In 2 cases (15%), we detected a space occupying lesion filling the cerebral aqueduct. A biopsy was taken from one of them. In another illustrative case, a tumor was seen filling the 3^{rd} ventricle, FoM, and cerebral aqueduct. We were able to extract this lesion and make CSF pathway patent. The lateral walls of the 3rd ventricle were seen which consists of the thalamus, hypothalamus with the hypothalamic sulcus in between. The 3 structures were seen obviously in one case (8%). Temporal lobe was seen in one case (8%) after penetration of the 3rd ventricular floor during ETV, lateral to brain stem.

DISCUSSION

Nagm A et al. [15] reported neuroendoscopy through extremely narrow FoM. In our study, we have shown varieties of FoM as narrow, wide, rotated and obliterated. In our study, we accessed the right and left one. Especially in narrow FoM, we make sure not to injure the columns of the fornix, besides, having a second look on the boundaries of FoM before we finish. Zohdi et al.[10] has described the anatomy of the velum interpositum and the 3rd ventricular roof. In our study, we have shown velum interpositum in 2 cases of the mentioned illustrative cases with labeled images in which the septum pellucidum was not found as it cannot be seen with intact septum pellucidum. Anik I et al. [16] has reported the anatomy of liliequist membrane (LM). In our research, we have viewed the LM with its parts (Diencephalic, mesencephalic and sellar parts), and its types (thin and thick). We also opened it during ETV in all cases of ETV using the fogarty catheter alone in thin LM while in thick type, we used the scissors and bipolar electrode forceps besides fogarty catheter. From the literature, it is mandatory to be opened for successful ETV. Sughrue M et al. [17] has reported the types of the 3rd ventricular floor. In our study, we have seen and viewed it in 10 cases with full description including its types. It was thin in 6 cases, thick in 4 cases. Also, it appears opaque in 6 cases, transparent in 4 cases. We used the dick forceps to make the ETV stoma, fogarty catheter to dilate it in almost all cases. In thick floor, we have used scissors and bipolar electrode besides the previous tools.

Limitation: Number of cases is not too many. This is because the deficiency of recording, and we intended to include cases of a single surgeon to limit skill errors. Also, we have made our efforts to include valuable cases with obvious images of a wide range of anatomical variations and surgical techniques.

CONCLUSION

Our study has presented and described numerous varities of normal and pathological neuroendoscopic anatomy in the form of neuroendoscopic video-captured images with labels and interpretation. Through viewing and describing these images, this study was able to participate in achieving safer surgical freedom. This freedom is represented in understanding the critical landmarks, besides, studying the accessibility and maneuverability for each target. It can help novice neurosurgeons to be ready and well prepared for several surgical challenges based on better anatomical understanding, necessary instrumentation, and skills.

REFERENCES

1. Walker M L. History of ventriculostomy. *Neurosurgery clinics of north America*, 12: 101-10, 2001.

2. Little A S, Douglas H. Endoscopic third ventriculostomy, Neuroendoscopic procedures. *Neuroendoscopic Surgery*. Thieme Publishers New York. 21(227), 2016.

3. Mortazavi M, Adeeb N, Griessenauer C J, Sheikh H, Shahidi S, Tubbs RI, Tubbs RS. The ventricular system of the brain: a comprehensive review of its history, anatomy, histology, embryology, and surgical considerations. *Child's Nervous System*, 30(1):19-35, 2014

4. Riegel T, Hellwig D, Bauer B L, Mennel H D. Endoscopic Anatomy of the Third Ventricle. *Acta Neurochirurgica*, 61:54-6, 1994.

5. Scelsi C L, Rahim T A, Morris J A, Kramer G J, Gilbert B C, Forseen S E. The Lateral Ventricles: A Detailed Review of Anatomy, Development and Anatomic Variations. *American Journal of Neuroradiology*, 41(4), 566-72, 2020.

6. Tubbs R S, Oakes P, Maran I S, Salib S, Loukas M. The foramen of monro: A review of its anatomy, history, pathology, and surgery, Child's Nervous System, 30(10):1645-9, 2014.

7. Shenoy S S, Lui F. Neuroanatomy, Ventricular System. StatPearls publishing, 2022.

8. Tubbs R S, Louis R G, Wartmann C T, Loukas M, Shoja M M, Apaydin N, Oakes W J. The velum interpositum revisited and redefined, Surgical and radiological anatomy, 30(2): 131-5, 2008.

9. Oka K, Go Y, Kin Y, Tomonaga M. An observation of the third ventricle under flexible fiberoptic ventriculoscope: *Normal structure, Surgical neurology* 40(4): 273-7, 1993.

10. Zohdi A, Elkheshin S. Endoscopic anatomy of the velum interpositum: A sequential descriptive anatomical study. *Asian journal of neurosurgery*, 7(1):12-6, 2012.

11. Dias D A, Castro F L, Yared J H, Junior A L, Ferreira N F, Filho L A. Liliequist membrane: radiological evaluation, clinical and therapeutic evaluation, *Radiologia Brasileira* 47: 182-5, 2014.

12. Elmaghrabi M, Ragab A, Zohdi A, Hussein F, Sakr S. Endoscopic anatomy of the liliequist's membrane. *Kasr Al-Ainy*, 2012.

13. Mortzavi M, Rizq F, Harmon O, Adeeb N, Gorjian M, Hose N, Modammadirad E, Taghavi P, Rocque B, Tubbs R S. Anatomical variations and neurosurgical significance of liliequist's membrane. *Child's Nervous System* 31(1): 15-28, 2015.

14. Nagm A. Neuroendoscopic video-captured Images: copyrights are reserved to Dr. Alhusain Nagm, 2021-2022.

15. Nagm A, Ogiwara T, Goto T, Chiba A, Hongo K. Neuroendoscopy via an Extremely Narrow Foramen of Monro, NMC Case Report Journal, 4(1):37-42, 2017.

16. Anik I, Ceylan S, Koc K, Tugasaygi M, Sirin G, Gazioglo N, Sam B. Microsurgical and endoscopic anatomy of liliequist's membrane and the prepontine membranes: Cadaveric study and clinical implications. *Acta Neurochirurgica*, 153(8): 1701-11, 2011.

17. Sughrue M, Chiou J, Burks J, Bonney P, Teo C. Anatomic variations of the floor of the third ventricle: an endoscopic study. *World Neurosurgery*, 90: 211-27, 2016.