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Hydrocephalus with lateral ventricular lesions: case series and review of literature

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Abstract

Background: Lateral ventricular lesions associated with hydrocephalus are considered a challenge to neurosurgeons. Hydrocephalus after surgery of such lesions and its pathogenesis and how to deal with it is a big question facing neurosurgeons.

Objectives: In this study, we tried to discuss the pathogenesis and different forms of presentation of hydrocephalus in lateral ventricular lesions and how to deal with it.

Methods: Eleven patients with lateral ventricular lesions associated with hydrocephalus either preoperative or postoperative presenting to our hospital were managed by excision of the lesion. A prospective study was done for these cases including their clinical data, radiological data, the presence, or absence of hydrocephalus either preoperative or postoperative and how we managed it.

Results: This study included 11 cases. The mean patient age at surgery was 25 years old. Nine cases were presented with radiological signs of hydrocephalus preoperatively. Two cases developed new onset hydrocephalus after lesion excision. Six cases ended with permanent CSF diversion.

Conclusion: Management of cases with lateral ventricular lesions does not stand on only excision of the lesion. Hydrocephalus should be kept into consideration perioperatively. We should try to avoid events that could lead to ventriculitis. Prolonged follow-up of the patients postoperative is very important as hydrocephalus may develop later after surgery.

Keywords: Lateral ventricular lesions, Hydrocephalus, CSF diversion

Introduction

Lesions of lateral ventricle are not only a challenge to neurosurgeons for their deep location, vascularity, or nearby vital neural structures, but also these lesions have incidence of association with hydrocephalus, either preoperatively, postoperatively, or both [1, 2]. As majority of these lesions are slowly growing low-grade pathologies, usually, these patients present with manifestations of increased intracranial pressure due to hydrocephalus [1, 2]. Presence of hydrocephalus preoperatively should be considered as determining factor for management, approach of surgery to the lesion, and determining the priority either to deal with hydrocephalus or the lesion at first [1, 2]. Persistence or occurrence of hydrocephalus after surgery, even with total removal of the lesions, raises the question about the pathogenesis of hydrocephalus, as according to the classic CSF circulatory theory of hydrocephalus that stands that removal of the obstructing element of CSF pathway should eliminate the incidence of hydrocephalus, which does not always occur, as there is high incidence of hydrocephalus with these lesions [3]. Another issue is how the hydrocephalus appears postoperatively and how to deal with it after surgery as there are many factors that should be considered as persistence of blood in CSF, possibility of infection and ventriculitis, presence of previous craniotomy, puncture of the lateral ventricle, and presence of gliosis within the ventricular system which may lead to compartmentalization [3].

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Methods

We performed a prospective study for cases with lateral ventricular lesions associated with hydrocephalus, either preoperative or postoperative, presented to our hospitals from January 2019 to April 2020. The aim of this study is to try to discuss the pathogenesis of hydrocephalus in lateral ventricular lesions after surgery and to discuss its different forms of presentation (including wound state, CSF pressure, ventricular size in imaging, and subdural effusion) and how to deal with it trying to avoid complications and repeated CSF diversion surgeries.

We recorded all the clinical data of the patients including preoperative clinical presentation and postoperative clinical condition (postoperative conscious level, manifestation of increased intracranial pressure, external ventricular drain (EVD) pressure, vital signs, wound state, and laboratory data). We considered all the radiological data including preoperative images, presence or absence of preoperative hydrocephalus, postoperative complications such as intraventricular hemorrhage, and presence or absence of signs of increased intracranial pressure in postoperative images like ventriculomegaly or subdural collection. CT scans were performed using the following machines: General Electric® rightspeed (USA) and Siemens® Somatom Emotion (Germany). MRI was performed using 1.5 T Siemens Magnetom Symphony Maestro Class, Syngo MR 2002B (Siemens Medical system Inc., Erlangen, Germany).

Regarding the surgical data, we recorded the approach of surgery, the radicality of excision of the lesions, and intraoperative complications. In some cases, we performed lumbar manometry to measure postoperative CSF pressure. Different scenarios of CSF diversions were reported such as preoperative ventriculoperitoneal (VPS) shunt insertion or temporary intraoperative CSF diversion using an external ventricular drain. In some cases, we inserted VPS in the same session of tumor excision. In other cases, we inserted VPS in a different session after tumor resection. The pathological data of the resected tumors were reported.

Results

This study series included 11 cases with lateral ventricular lesions associated with hydrocephalus, either preoperative or postoperative. The mean patient age at surgery was 25 years old (range 6 years old to 55 years old).

Out of the 11 cases, two cases presented with disturbed conscious level, and the other cases presented with manifestations of increased intracranial pressure.

Out of 11 cases, 9 cases were presented with sure radiological signs of hydrocephalus preoperatively. One case of those 9 cases who have preoperative hydrocephalus survived and did not need permanent CSF diversion, and hydrocephalus resolved and the pathology revealed meningioma grade 1 and lesion excision alone cured the case (case number 6 in the master table). The remaining 2 cases of our patients who had no preoperative hydrocephalus developed immediate postoperative hydrocephalus. Hydrocephalus resolved spontaneously in one case after 3 days, and the pathology revealed meningioma grade 1 (case number 4 in the master table). In the other case, the hydrocephalus became permanent and VPS was inserted (case number 3 in the master table).

Pathology of the two cases who did not develop permanent hydrocephalus and did not need permanent CSF diversion (case numbers 4 and 6 in the master table) was meningioma grade 1. The other pathologies were three cases central neurocytoma, one case subependymoma G1, one case arteriovenous malformation, one case subependymal giant cell astrocytoma, one case pilocytic astrocytoma, one case of astrocytoma G2, and one case of oligodendroglioma G3.

All the cases underwent gross total resection, 10 cases were operated via transcortical approaches (5 cases via trans middle frontal gyrus and 5 cases via trans superior parietal lobule), and one case was operated via transcallosal approach.

Out of the 11 cases, perioperative complications occurred in 4 cases. In a case, there was massive intraoperative bleeding upon which the patient had a massive blood transfusion, EVD was inserted at the end of the surgery, and the postoperative patient experienced acute respiratory distress upon which patient was ventilated for 10 days and died. During these 10 days, the EVD showed elevated intracranial pressure upon which EVD was used for intermittent CSF drainage with trial of gradual weaning from EVD (case number 7 in the master table).

The other case showed marked intraventricular hemorrhage in postoperative image; EVD was inserted intraoperative, which was placed at level 5 cm from the foramen of Monrow for drainage of bloody CSF, which started to clarify after 3 days. Gradual weaning of EVD was done for another 3 days then EVD was removed. After 3 days of removal of EVD, the patient started to develop subgaleal collection, headache, and hydrocephalic changes in CT brain in form of ventriculomegaly, upon which ventriculoperitoneal shunt (VPS) was inserted (case number 8 in the master table).

Another case had an injury to one of the deep ventricular veins, upon which follow-up CT brain showed thalamic infarction. In this case, EVD was placed at the end of the surgery and showed borderline readings of intracranial pressure, upon which the drain was used for intermittent drainage of CSF. The patient started to experience fever in the second day after surgery. In the fifth day, the total leukocytic count in CSF showed marked elevation upon which the patient was diagnosed to have ventriculitis. Intravenous and intraventricular injection of antibiotics according to culture and sensitivity of the CSF was used, and the EVD system was changed after 10 days, but unfortunately, the patient died after 20 days. While that 20 days, the EVD pressure readings raised. CT started to reveal subdural effusion from the 5th day as a sign of increased intracranial pressure (case number 9 in the master table).

Another case started to experience fever in the third day after surgery. Total leukocytic count in CSF was elevated. Intravenous and intraventricular injection of antibiotics according to culture and sensitivity of the CSF was used. Postoperative conscious level was 8 on Glasgow Coma Scale. The EVD pressure readings were high. Unfortunately, the patient died after 9 days. While that time, CT follow-up revealed ventriculomegaly as a sign of hydrocephalus (case number 11 in the master table).

Out of 11 cases, EVDs were inserted intraoperatively in 8 cases. In one case, EVD was inserted intraoperatively, which was placed at level 5 cm from foramen of Monrow for drainage of bloody CSF, which started to clarify after 3 days. Gradual weaning of EVD was done for another 3 days, and then EVD was removed. After 3 days of removal of EVD, the patient started to develop subgaleal collection, headache, and hydrocephalic changes in CT brain (ventriculomegaly), upon which ventriculoperitoneal shunt (VPS) was inserted (case number 8 in the master table). In the other 7 cases, EVD was used to measure intracranial pressure postoperatively.

Gradual weaning of EVD was practiced in all 8 cases. The weaning of EVD was successful only in one case (case number 6 in the master table). One case showed high pressure readings and weaning of EVD failed and VPS was inserted (case number 1 in the master table). Three cases showed either low or borderline pressure readings and the EVD was removed but the hydrocephalus gradually developed, and VPS was inserted later (cases 5, 8, and 10 in the master table). Two cases with EVD developed ventriculitis and died (case numbers 9 and 11 in the master table). One case with EVD died from bad chest condition (case number 7 in the master table).

In 3 cases, we did not insert EVD intraoperatively as we found the field of surgery was very clear and the lesions were totally excised (cases 2, 3, and 4 in the master table). Two cases of them gradually developed hydrocephalus and needed permanent CSF diversion later on (cases 2 and 3 in the master table), and the other case passed without the need of permanent CSF diversion (case 4 in the master table).

Out of the 11 cases of this study, two cases (of meningiomas) have passed the barrier of hydrocephalus with its drawbacks without second surgery for CSF diversion (case numbers 4 and 6 in the master table). Three cases died with EVDs (cases 7, 9, and 11 in the master table). Six cases ended with permanent VPSs (cases 1, 2, 3, 5, 8, and 10 in the master table).

In three cases of the study, the first signs of hydrocephalus postoperatively were not ventriculomegaly. In two cases, subdural effusion was the first sign (cases 2 and 9 in master table), and in the third case, it accumulated CSF along the corridor of transcortical approach communicating outside to the subdural space and inside with the lateral ventricle (case 3 in the master table). Ventriculomegaly was the first sign of hydrocephalus postoperatively in 6 cases. Four ended by inserting a VPS (cases 1, 5, 8, and 10 in the master table). And 2 cases died with EVDs before inserting VPSs (cases 7 and 11 in the master table).

In a case which developed communicating hydrocephalus after surgery (in the form of subdural effusion and subgaleal tense collection), lumbar manometry was done two times for intracranial pressure monitoring and as a trial for treating hydrocephalus by stimulation of the CSF circulation in the subarachnoid space (case number 2 in the master table). CSF pressure was high in the two readings (35 and 40 cm H_2O), with temporary relief of headache and subgaleal collection for 1 day then progression of the manifestations. So, VPS was inserted.

Out of the six cases that ended with VPSs, in five cases, ventricular catheters of the shunts were placed at the site of surgical ventriculostomy; in four cases, CSF drainage was adequate without compartmentalization or appearance of extra-axial collections in follow-up, and there was no need to do redirection of the catheter or shunt revision. In the fifth case, horn entrapment occurred upon which endoscopic fenestration was done with ventricular catheter redirection. In one case, the ventricular catheter was placed opposite the side of surgery of lesion excision, and this case underwent multiple shunt revision surgeries later. The summary of the above results is shown in the Table 1.

All the data of our cases are discussed in the master table (Table 2). And here, we discuss two of our cases in details

Case 2 in the master table

Six-year-old patient presented with manifestations of increased intracranial pressure with cutaneous signs of tuberous sclerosis. The patient underwent surgery for gross total resection of the lesion via the left middle frontal gyrus approach. At the end of the surgery, hemostasis was adequate, the tumor was totally removed, and no EVD was inserted. The patient has smooth recovery without deficits. Histopathology

Table 1 The summary of our results

	Frequencies	Percentage
Presentation		
Disturbed conscious level	2	18.2%
Increased intracranial pressure	9	81.8%
Sure radiological signs of hydrocephalus preoperatively		
+VE	9	81.8%
−VE	2	18.2%
Pathology		
Central neurocytoma	3	27.3%
Meningioma grade 1	2	18.2%
Subependymoma G1	1	9.1%
Arteriovenous malformation	1	9.1%
Subependymal giant cell astrocytoma	1	9.1%
Pilocytic astrocytoma	1	9.1%
Astrocytoma G2	1	9.1%
Oligodendroglioma G3	1	9.1%
Approaches		
Trans middle frontal gyrus	5	45.5%
Trans superior parietal lobule	5	45.5%
Transcallosal approach	1	9.1%
Complication		
Bleeding	2	18.2%
Ventriculitis	2	18.2%
No complications	7	63.6%
EVD		
+VE	8	72.7%
−VE	3	27.3%
Lumbar manometry		
+VE	1	9.1%
−VE	10	90.9%
Permanent CSF diversion		
+VE	6	54.5%
−VE	5	45.5%
Fate		
Permanent VPSs	6	54.5%
Death with EVDS	3	27.3%
No second surgery for CSF diversion	2	18.2%
First signs of hydrocephalus postoperatively		
Ventriculomegaly	6	54.5%
Subdural effusion	2	18.2%
Accumulated CSF along the corridor of transcortical approach	1	9.1%

revealed that the lesion is subependymal giant cell astrocytoma. Computed tomography (CT) scan was done 1 day after surgery and showed gross total resection without hematomas with small bilateral extra-axial CSF collection (subdural effusion) more ipsilateral to the side of surgery. Two weeks after surgery, the patient started to complain of headache and subgaleal collection, and the condition progressed till 1 month after surgery.

Table 2 The master table of our cases

	1	2	3	4	5	6	7	8	9	10	11
Age	15 years	6 years	8 years	25 years	20 years	45 years	15 years	19 years	55 years	18 years	46 years
Sex	Female	Male	Female	Female	Female	Female	Female	Male	Female	Female	Female
Preoperative hydrocephalus	+	+	–	–	+	+	+	+	+	+	+
Surgical approach	Transcortical left middle frontal gyrus	Transcortical left middle frontal gyrus	Transcortical right superior parietal lobule	Transcortical right superior parietal lobule	Transcortical right superior parietal lobule	Transcortical right superior parietal lobule	Transcortical right superior parietal lobule	Transcortical left superior parietal lobule	Transcortical right middle frontal gyrus	Transcortical middle frontal gyrus	Transcallosal
Gross excision	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total
EVD	+	–	–	–	+	+	+	+	+	+	+
Fate or postoperative hydrocephalus	Postoperative CT revealed ventriculomegaly and EVD pressure was high.	Subgalial collection after 2 weeks. then After 1-month CT re vealed subdural effusion with no ventriculomegaly.	Headache after 2 weeks. CT revealed accumulated CSF along the corridor of surgery. Then After 1-month CT showed more CSF accumulated along the corridor and enlarged ipsilateral temporal horn.	Immediate CT postoperative revealed early hydrocephalic changes and small hematoma at tumor bed. Clinically there was mild manifestation of increased ICP with no clinical deterioration on follow up. After 3 days hydrocephalus resolved.	EVD pressure readings are borderline for 2 days. The EVD removed and the patient followed up. 5 days later subgalial collection developed and CT showed hydrocephalic signs and ventriculomegaly.	CSF pressure was low for 2 days, the EVD was removed.	The tumor was huge and very vascular with intraoperative excess bleeding and the patient postoperative GCS was 5. CT postoperative revealed ventriculomegaly and EVD pressure readings was high. The patient died after 10 days.	Immediate CT postoperative revealed Intraventricular hematoma. EVD was used for drainage of blood for 3 days then another 3 days for measuring CSF pressure which was borderline and the EVD was removed. 3 days later subgalial collection developed and ventriculomegaly appears in CT brain.	CSF pressure readings was border line. Unfortunately, the patient started to experience fever from 2nd day after surgery due to ventriculitis. So the EVD was not removed (changed after 10 days) and the patient died after 20 days. While the 20 days the EVD pressure readings raised. CT started to reveal subdural effusion from the 5th day as sign of increased intracranial pressure.	CSF pressure readings was low for 3 days and EVD was removed. 8 days after surgery subgalial collection developed and ventriculomegaly started to appear in CT.	CSF pressure was high. Unfortunately, the patient started to experience fever from 3rd day after surgery and CSF TLC was high (ventriculitis). Postoperative GSC was 8. The EVD was not removed and the patient died after 9 days. While that time CT follow-up revealed ventriculomegaly.
Lumbar manometry	–	Done twice	–	–	–	–	–	–	–	–	–
Permanent CSF diversion	+ VPS	+ VPS	+ VPS	–	+ VPS	–	–	+ VPS	–	+ VPS	–
Pathology	Central neurocytoma	Subependymal giant cell astrocytoma	AVM	Meningioma G1	Astrocytoma G2	Meningioma G1	Central neurocytoma	Central neurocytoma	Oligodendroglioma	Pilocytic astrocytoma	Subependymoma
Complication	–	–	–	–	–	–	Excessive intraoperative bleeding	Postoperative intraventricular bleeding	▪ Injury to deep vein resulting in thalamic infarction. ▪ Ventriculitis	–	Ventriculitis

Lumbar puncture was done which showed elevated pressure (35 cm H2O) (Fig. 1).

The patient underwent the first VPS surgery by inserting right posterior parietal medium pressure shunt (contralateral to excision surgery) with smooth recovery. Two weeks later, the patient presented with marked headache with CT brain showing marked left side extra-axial collection (contralateral to the shunt and ipsilateral to tumor surgery) (Fig. 2a). The first shunt was withdrawn from the right lateral ventricle and reinserted in the left subdural space with smooth recovery. Three weeks later, the patient presented with severe headache with CT brain showing right-sided chronic subdural hematoma (contralateral to the shunt) (Fig. 2b).

Evacuation of hematoma was done with the removal of the subduroperitoneal shunt with smooth recovery. The patient was followed meticulously till 5 days after surgery, as he developed headache again. Lumbar puncture was done which revealed increased pressure (40 cm H2O), upon which the thecoperitoneal shunt was placed. Two days later, the patient developed deterioration of conscious level with CT brain showing marked hydrocephalus (Fig. 3a) upon which urgent VPS was placed (right posterior parietal high pressure) with the removal of the thecoperitoneal shunt (Fig. 3b). The patient started to recover gradually with full recovery 1 day after surgery without complaining of headache with nice follow-up in the outpatient clinic.

Case 3 in the master table

Eight-year-old patient presented with disturbed conscious level with images showing hemorrhagic lesion in trigon of the right lateral ventricle. Urgent surgical excision via superior parietal lobule was done with gross total resection of the lesion and adequate hemostasis without insertion of EVD. The patient experienced gradual recovery over a week with follow-up CT brain 1 day after surgery showing total excision of the lesion and no signs of hydrocephalus (Fig. 4). Histopathology revealed arteriovenous malformation and immunohistochemistry excluded the presence of tumor cells.

Two weeks after surgery, the patient started to complain of headache with follow-up CT brain showing enlarged CSF accumulation at the site of surgical approach communicating with subdural space externally and temporal horn internally (Fig. 5a). The condition was followed for another 3 weeks; during this period, headache progressed and became associated with vomiting and blurring of vision, with follow-up CT brain showing hydrocephalus with marked enlargement of temporal horn and trigon ipsilateral to the site of surgery and midline shift (Fig. 5b). Right posterior parietal (ipsilateral to the site of previous surgery) VP shunt was inserted with smooth recovery and regression of manifestations of increased intracranial pressure and nice follow-up in the outpatient clinic (Fig. 5c).

Discussion

The management of hydrocephalus in patients with surgically resectable lateral ventricular lesions remains a great challenge and controversial. Gross total lesion excision, even with low-grade pathologies, is not a safeguard against developing hydrocephalus [3]. So, hydrocephalus pathogenesis with lateral ventricular lesions is not only due to obstruction of CSF pathway, with taking into consideration the classic CSF circulatory theory, but it was also assumed that communicating hydrocephalus in these cases occurs due to many factors as high protein content and blood in CSF affect arachnoid granulations, inflammatory process in subarachnoid space takes place due to subarachnoid blood and proteins and affection of dural sinuses during craniotomies [3]. Recent studies raised the suspicion against the classic circulatory CSF theory that assumes that CSF is mainly formed by choroid plexuses, mainly in lateral ventricles, circulating from lateral, third, and fourth ventricles to subarachnoid space to arachnoid villi to end in dural venous sinuses [4, 5]. Recent studies suggest that Virchow Roben spaces are the main site for CSF

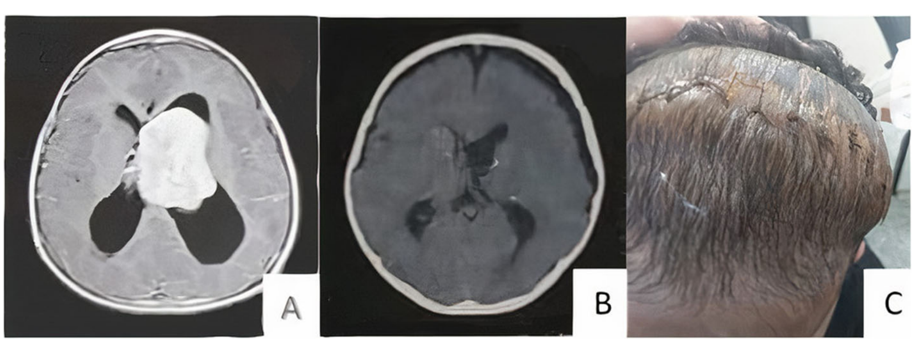

Fig. 1 **a** Preoperative MRI. **b** CT brain 1 day after surgery. **c** Subgalial collection

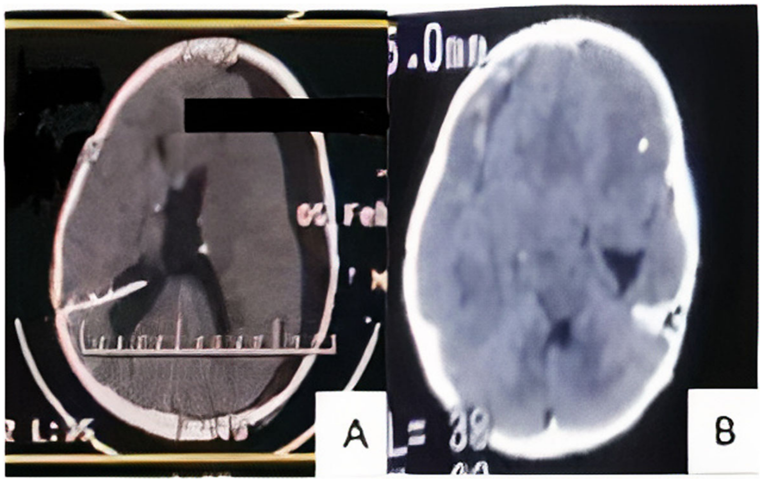

Fig. 2 **a** CT brain 2 weeks after the first shunt. **b** CT brain 3 weeks after the second shunt (left subduroperitoneal shunt)

secretion and absorption and that ventricular CSF is communicating with interstitial fluid, and both react as one functional unit [4, 5]. Also, these studies suggest that lymphatics within an olfactory bulb and petrous bone have a role in CSF absorption, eventually draining into cervical lymphatics, and these lymphatics have a role in the regulation of the osmotic environment of CSF [6]. These studies also assume that there are two main sources controlling the process of CSF secretion and absorption within Virchow Roben spaces, the hydrostatic and osmotic pressures [4, 7]. It was proved that brain lesions affect cerebral blood flow and its regional distribution, and not always these changes normalize after excision of these lesions [8]. With brain lesion surgery, especially intraventricular lesions, many changes occur to CSF constitutes and osmolarity, and not usually normalize after lesion excision [9]. Elevated CSF proteins are not assumed only to affect CSF osmolarity, they are assumed to affect the function of aquaporin channels that transfer water molecules, so not only the amount or osmolarity of proteins secreted into CSF affect the process, also types of these proteins [7, 9]. All these factors could explain the possibility of the persistence of hydrocephalus after lateral ventricular lesion excisions and the tendency of resolution of hydrocephalus with some pathologies like meningiomas.

Intraoperative placement of EVDs after lesion excision is preferred by many authors, as it helps for drainage of intraventricular hemorrhage if present, helps in intracranial pressure monitoring and for CSF drainage if needed. So, it acts as a safeguard against sudden death from hydrocephalus. Others do not prefer to insert EVDs, especially when adequate hemostasis is performed after lesion excision for fear of infection and the assumption that presence of EVD will disturb CSF circulation resulting in shunt dependency [10]. In our study, we have two mortalities from ventriculitis, and the two cases underwent EVD placement at surgery of lesion excision. A

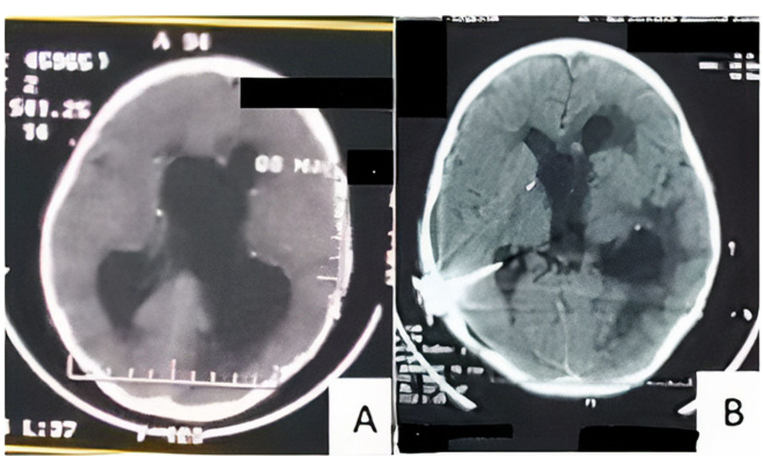

Fig. 3 **a** CT brain 2 days after thicoperitoneal shunt. **b** CT brain after high-pressure shunt

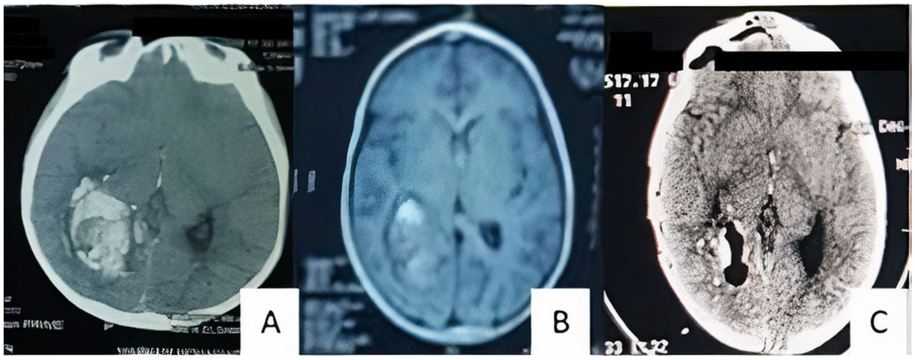

Fig. 4 a Preoperative CT brain. **b** Preoperative MRI without contrast. **c** CT brain 1 day after surgery

case of our study has got benefit from EVD, as peri-operative intraventricular hemorrhage occurred, upon which EVD was set at low pressure, which helped to drain the hemorrhage over 3 days. As regards the role of EVDs in pressure monitoring for predicting which cases will be shunt dependent, we found that 5 cases in our study had low and borderline measures in the 3 days after surgery, and only one case ended with resolution of hydrocephalus from these cases. So, low or borderline pressure in the few days after surgery is not a safeguard that these patients will not develop hydrocephalus.

Keyvan Mostofi and colleagues revealed that gradual increasing of intracranial pressure by gradual weaning of EVDs by its gradual elevation in patients presented with acute hydrocephalus following a neurosurgical procedure or hemorrhage or trauma helps to stimulate CSF circulation and help in the resolution of hydrocephalus without shunt dependency [11]. Out of the 12 cases of Keyvan Mostofi and colleagues' cases, four cases could not tolerate the increase of CSF pressure, so they underwent VPS, and the other eight cases became shunt independent. In our study, we tried to do gradual weaning of EVDs, and only one case ended with the resolution of hydrocephalus without shunt dependency. Presence of hydrocephalus preoperatively in our cases for a chronic period may be a factor of failure of stimulation of CSF circulation by this maneuver. In addition to that, we tried to stimulate CSF circulation in one of our cases by doing lumbar puncture with drainage twice, which failed to control hydrocephalus.

Subdural effusion with hydrocephalus (SDEH) or adult-type external hydrocephalus has been reported in literature; these terms used to describe the presence of extra ventricular cerebrospinal fluid (CSF) collections accompanied by hydrocephalus, without ventriculomegaly, particularly in cases of adults suffering from aneurysmal subarachnoid hemorrhage, severe head injuries, and after decompressive craniotomies, which may be explained by escape of CSF from arachnoid tears or defects into subdural space [12]. Yosef Ellenbogen and colleagues documented that uncal herniation has occurred after intraventricular tumor excision due to external hydrocephalus (SDEH) without ventriculomegaly [13]. Yosef Ellenbogen and colleagues case presented with deteriolated neurological functions with images showing bilateral subdural effusion (external hydrocephalus), upon which twist drill craniostomy was performed in one side and a subdural drain was left in place. The CSF egress

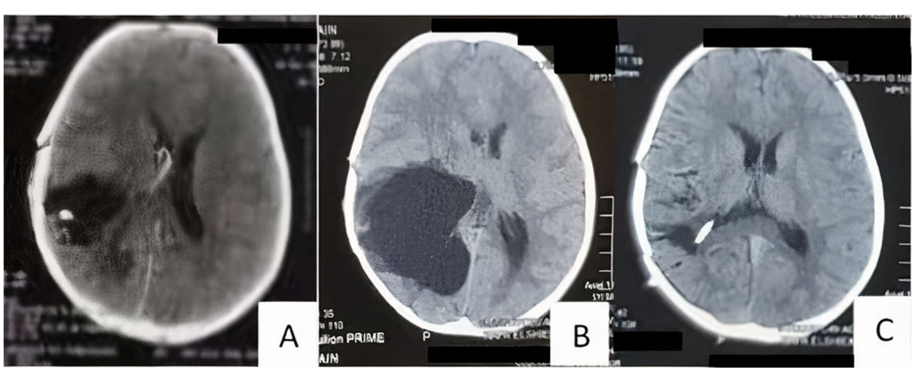

Fig. 5 a CT brain 2 weeks after surgery. **b** CT brain 5 weeks after surgery. **c** CT brain after VP shunt was under high pressure. A post-procedure CT demonstrated reduction in the subdural collection. MRI with CSF flow study at that time only showed slightly diminished CSF flow at the cervicomedullary junction with a bilaterally patent foramen of Monro. Their patient continued to improve with subdural drainage and returned to her neurological and functional baseline over the next 2 days. Then VPS was inserted with the removal of subdural drains. They suggested that redistribution of CSF along the recently established surgical tract from the surgical open ventriculostomy into the subdural space. Further, CSF analysis showed elevated protein (1.2 g/L) which may have contributed to reduced CSF absorption. Thus, a right-sided ventriculoperitoneal shunt was inserted. In our study, two cases showed subdural effusion without ventriculomegaly and proved to have increased intracranial pressure by clinical manifestations and manometry (a case via EVD, the other via lumbar puncture). A third case in our study showed accumulated CSF in the corridor of transcortical approach communicating outside to the subdural space and inside with the lateral ventricle without ventriculomegaly, progressed to cause midline shift and effaced brain sulci without ventriculomegaly. These events highlight the need to carefully observe patients post intraventricular surgery when subdural effusion or accumulated CSF at the approach site appear, especially in symptomatic patients within the first few postoperative weeks, and also should be differentiated from hygromas, as hygromas have different management. Tzerakis and colleagues supposed that VPS should be efficient in treating SDEH, rather than twist drill craniostomy nor subduroperitoneal shunt [12].

Management of hydrocephalus after intraventricular lesion excision surgery is complicated in decision, as there are many clinical and radiological forms of hydrocephalus as mentioned before and carries the risk of multiple interventions with the shunt. This is due to abnormalities in CSF composition after surgery (high protein content), remnants of blood, changes in regional cerebral blood flow around tumor side, wide open ventriculostomy done during lesion excision surgery and possibility of infection [3]. Ekkehard Kasper and colleagues' study correlated shunt failure after partial subependymal giant cell astrocytoma excision to high proteins in CSF, and after redo surgery to the lesion and total excision, normalization of CSF occurred after a while and VPS placement showed adequate follow-up and proper functions [9]. Laviv Y and colleagues demonstrated many cases in whom multiple shunt failures occurred after subtotal removal excision of subependymal giant cell astrocytoma, CSF of these cases showed marked elevation of CSF proteins. Laviv Y and colleagues used everolimus to decrease CSF proteins with subependymal giant cell astrocytomas in tuberous sclerosis patients, without total resection of the tumors, upon which normalization of CSF proteins occurred and VPSs were functioning adequately [14]. In our study, out of the 6 cases that ended with permanent VPSs, two cases underwent redo surgery of CSF diversion.

Conclusion

Management of cases with lateral ventricular lesions does not stand on only excision of the lesion; hydrocephalus should be kept into consideration perioperative and during the period of follow-up. We recommend inserting EVD in all cases postoperatively to help to measure CSF pressure, but we also should take all measures to avoid infection and ventriculitis from EVD as it may result into adverse outcomes. Prolonged follow-up of the patients postoperative clinically and radiologically is very important as hydrocephalus may develop later after surgery. We should not diagnose hydrocephalus only by ventriculomegaly, but it may also be diagnosed by either subdural effusion or accumulation of CSF along the corridor of surgery without marked ventriculomegaly. We also recommend if we are going to insert VPS, it is better to insert the proximal end at the site of surgery.

Abbreviations

CSF: Cerebrospinal fluid; CT: Computed tomography; EVD: External ventricular drain; G: Grade; ICU: Intensive care unite; SDEH: Subdural effusion with hydrocephalus; VPS: Ventriculoperitoneal shunt; GCS: Glasgow Coma Scale; TLC: Total leukocytic count

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Authors' contributions

AMA, AHA, and ATM conceived the study, participated in its design and coordination, and helped to draft the manuscript. AMA and ATM performed data acquisition and its analysis. AHA reviewed the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This observational study was approved by the ethics committee of the Department of Neurosurgery, Kasr Alainy Faculty of Medicine, Cairo University on the 9th of December 2018.
The committee's reference number is not available.
All participants provided informed written consent to participate in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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