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Intraoperative precautionary insertion of external ventricular drainage catheters in posterior fossa tumors presenting with hydrocephalus

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KEYWORDS

Posterior fossa tumors;
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Abstract *Introduction:* Hydrocephalus in association of posterior cranial fossa tumors (PFT) remains a matter of controversy; whether to perform cerebrospinal fluid (CSF) diversion prior to tumor resection, or to perform direct tumor resection.
Objective: The aim of this study is to assess the risks and benefits associated with routine intraoperative insertion of external ventricular drainage (EVD) catheters in patients with PFT presenting with hydrocephalus.
Methods: Forty two patients with PFT with secondary hydrocephalus had intraoperative insertion of an external ventricular drainage catheter, it was kept closed, unless intraoperative lowering of the intracranial tension was needed, or opened postoperatively in cases of persistent hydrocephalus, CSF leak, in certain cases throughout and after the procedure.
Results: Eight cases (19%) needed opening of the drainage system during surgery to lower the intracranial tension. In the postoperative period, twelve cases (28.5%) needed opening of the EVD for the persistence of hydrocephalus, occurrence of CSF leak or bloody CSF. Only eight cases (19%) needed permanent CSF shunting, seven of which were ependymomas and medulloblastomas. None of the cases in this series acquired any EVD related infection, nor did those who required subsequent permanent CSF diversion.

Abbreviations: PFT, posterior cranial fossa tumors; CSF, cerebrospinal fluid; ICP, intracranial pressure; EI, Evans index; EVD, external ventricular drainage; VRI, ventriculostomy-related infection; IVH, intraventricular hemorrhage; ETV, endoscopic third ventriculostomy.

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Conclusion: Intra-operative insertion of EVD catheter during surgery of posterior fossa tumors, as it allows better control of the ICT during surgery if needed, provides a life saving emergency CSF drainage outlet if tumor resection fails to resolve HC or for the occurrence of de novo HC, and finally it provides adequate control of CSF leak in cases with supratentorial ventriculomegaly, where the use of lumbar drains may be hazardous. Intraoperative drainage prevents possible complications met with early CSF diversion. But the application of this technique should better be restricted to midline posterior fossa tumors related to the ventricular system.

Treatment of hydrocephalus in association of posterior cranial fossa tumors remains a matter of controversy; whether to perform cerebrospinal fluid (CSF) diversion prior to tumor resection, or to perform direct tumor resection, as spontaneous resolution of the hydrocephalus might be excepted. A patient presenting with hydrocephalus in association of a posterior fossa tumor; may be considered to have two distinctly different pathologies which complicate one another and contribute to the complex picture of increasing intracranial pressure (ICP): (1) the lesion itself, and (2) hydrocephalus.[1] Changes in cerebral blood flow that results from an increase in ICP and ventricular dilatation must also be considered in the pathogenesis of disease.[1]

Cushing used to place separate burr holes routinely in the operations on the posterior fossa tumors to drain the ventricles, in an attempt to prevent the life threatening effects of hydrocephalus.[2] Many surgeons advocate shunting procedures prior to tumor resection, with improvements in the preoperative diagnosis of hydrocephalus.[3–7] Other authors refrain from ventricular decompression, as it may result in sudden decrease in ICP, and some cases have been reported to develop epidural or intra-tumoral hematoma, which may have ominous consequences. These complications of shunting have raised the question of its application and they suggested that preoperative shunting makes the subsequent tumor excision even more difficult and hazardous, so they suggest that preoperative shunting for posterior fossa tumors is not frequently indicated, as only a portion of the cases that have not undergone preoperative shunting will need it after the operation.[8–10]

External ventricular drainage (EVD) has been considered one of the options in the management of hydrocephalus, in patients with posterior fossa tumors. However, the main disadvantage of EVD is the risk of contracting a ventriculostomy-related infection (VRI), which has been reported to affect 0.0–21.9% of patients.[11–16] Many modifications in the technique and duration of EVD application have greatly minimized this risk.[17–21]

1. Aim of the work

The aim of this study is to assess the risks and benefits associated with routine intraoperative insertion of external ventricular drainage (EVD) catheters in patients with PFT presenting with hydrocephalus.

2. Patient and methods

Forty two patients with posterior fossa tumors with secondary hydrocephalic ventricular dilatation were included in this study, from the year 2007–2013. The aim of this study was to assess the risks and benefits associated with routine insertion of EVD in such cases.

The location of the EVD was calculated on an individual basis depending on the measurements obtained from patients' radiological studies, then prior to patient positioning the site EVD burr-hole, midline and the cranio-caudal trajectory were marked on the patients scalp, to minimize the three dimensional and anatomical orientation confusion following positioning and draping of the patient. All patients were operated upon in prone or three quarters prone position. After finishing the bony work of both the posterior fossa and the EVD burr-hole, the posterior fossa dura is then opened, before opening the EVD burr-hole dura and attempting ventricular taping, to minimize the risk of upward conning and time to tumor exposure. Once intraventricular location of the catheter is confirmed by the least amount of CSF egress, the tube is then tunneled a distance of more than 5 cm to emerge through a separate incision away from that of the burr-hole incision and is attached to the collecting system. The external drainage system is kept closed intra-operatively unless other measures to lower the intracranial tension failed; where it is temporarily opened till adequate tumor removal, then it is re-closed at the end of the procedure. In cases where there was intraventricular hemorrhage (IVH), CSF drainage is permitted till it becomes clear.

The drainage system is kept closed to allow the build of the normal CSF pressure to maintain normal flow. If the patient developed signs of increasing ICT, deterioration of the level of consciousness or the occurrence of CSF leak, a computed tomography is performed to detect the cause. The collecting device is opened in case of persistence of hydrocephalus till definitive CSF diversion procedure is performed and also in case of CSF leak whether or not due to hydrocephalus till cessation of the leak.

3. Results

The most common age group affected was between 3 and 12 years amounting for 78.5%, as 33 patients had pediatric posterior fossa tumors. Five patients (12%) were above the age of 50 years; three cases of solitary cerebellar metastasis (two cases with tumor apoplexy with bleeding extending to 4th and 3rd ventricles), and two cases of tentorial meningiomas. Three cerebello-pontine angle and a fourth ventricular tumor, were in the fourth and third decades. In our series 29 (69%) were males and 13 (31%) were females, with a male to female ratio of 2.2:1. In the pediatric group, headache was the most common presentation in 75.7% of patients, followed by vomiting 51.5% and 45.5% with papilledema, diminution of vision and diplopia was noted in 15.1% and 12.1%, respectively. One patient was blind upon presentation. In adult groups headache was seen in 80%. Nuchal pain as one of the presenting features was seen in 9.5% of patients. Cerebellar symptoms were seen in 51% of cases. Twenty patients (47.6%) of the study population started having symptoms only one month prior to their presentation (See Figs. 1–4 and Table 1).

Fourteen (33%) cases were pathologically confirmed to be ependymoma, sixteen medulloblastoma (38%), and three pilocytic astrocytoma (7%). Intraoperative opening of the drainage system was performed in five cases, three ependymomas and two medulloblastomas, aiming to reduce the intracranial tension after the failure of other measures. At the end of surgery the drainage system was closed. On the third postoperative day five cases (3 medulloblastoma and 2 ependymoma) had deterioration of their level of consciousness, while three cases (an ependymoma, a medulloblastoma and a pilocytic astrocytoma) developed CSF leak. CT revealed persistence of the hydrocephalus in these eight cases, thus the drainage system was temporarily opened. The CSF was clear in all cases except the pilocytic astrocytoma, where it was blood tinged. The former cases had permanent CSF diversion surgery performed; while in the pilocytic astrocytoma neither did the CSF leak nor did the hydrocephalus recur after closure of the drainage system at the eighth postoperative day.

The three suspected cerebellar metastases (7%) were confirmed to be, metastatic papillary thyroid carcinoma, metastatic small cell carcinoma from the lung, and a case metastatic prostatic adenocarcinoma, in the former two cases hemorrhage within the tumor extended to the fourth ventricle. The drain was left open to allow intra-ventricular blood drainage and closed once CSF becomes clear, which occurred at a mean of five and half days. The closed drainage system was left as an emergency valve, for further two more days to observe any signs of ICT. None of the metatstatic cases required permanent CSF diversion.

The CP angle tumors were confirmed to be two vestibular and one Trigeminal schwannoma, intra-operative opening of the EVD in one of the former and the latter to minimize cerebellar herniations and excessive retraction, thus providing adequate tumor exposure. One of the cases had a CSF leak which was controlled by temporary EVD opening, then permanent V–P shunting through a contra-lateral frontal burr hole.

The fourth ventricular tumor was a choroid plexus papilloma. EVD was temporarily opened to control CSF leak which appeared on the fourth postoperative day. Control of this leak was accomplished by 7th postoperative day, with no need of permanent shunting, although a pseudo-meningocele was present in the post-operative follow up MRI. Two cases with tentorial meningioma were excised with only one requiring intra-operative EVD opening.

In total eight cases (19%) needed opening of the drainage system during surgery to lower the intracranial tension. In the postoperative period, twelve cases (28.5%) needed opening of the EVD for the persistence of hydrocephalus, occurrence of CSF leak or bloody CSF. Only eight cases (19%) needed

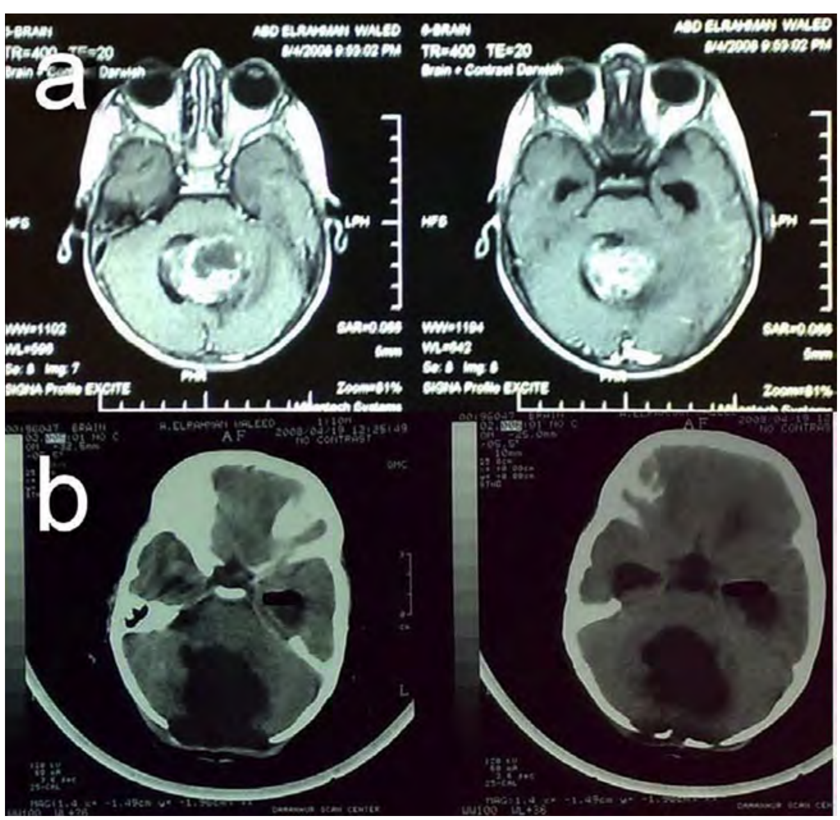

Figure 1 (a) Preoperative MRI for a case of medulloblastoma, (b) postoperative CT revealing the persistence of HC necessitating permanent V–P shunting.

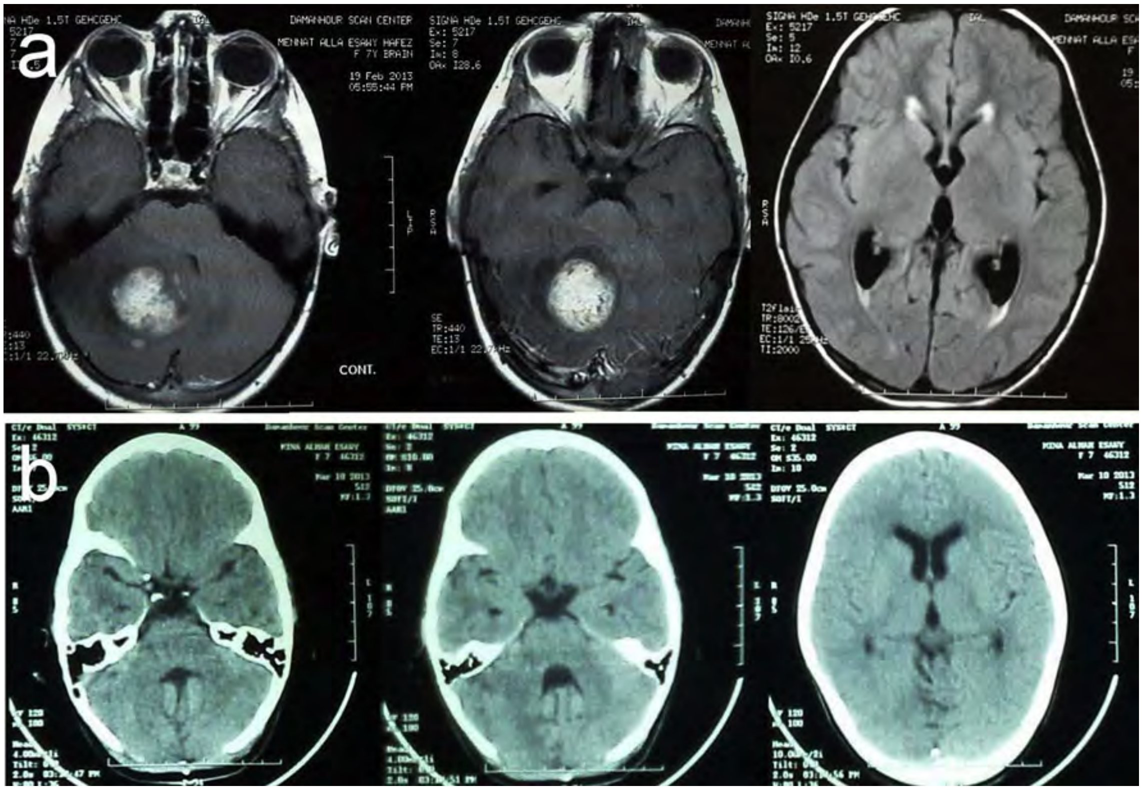

Figure 2 (a) Preoperative MRI of a pilocytic astrocytoma, with mass effect occluding the 4th ventricle, causing obstructive HC. (b) Postoperative CT complete tumor excision without HC.

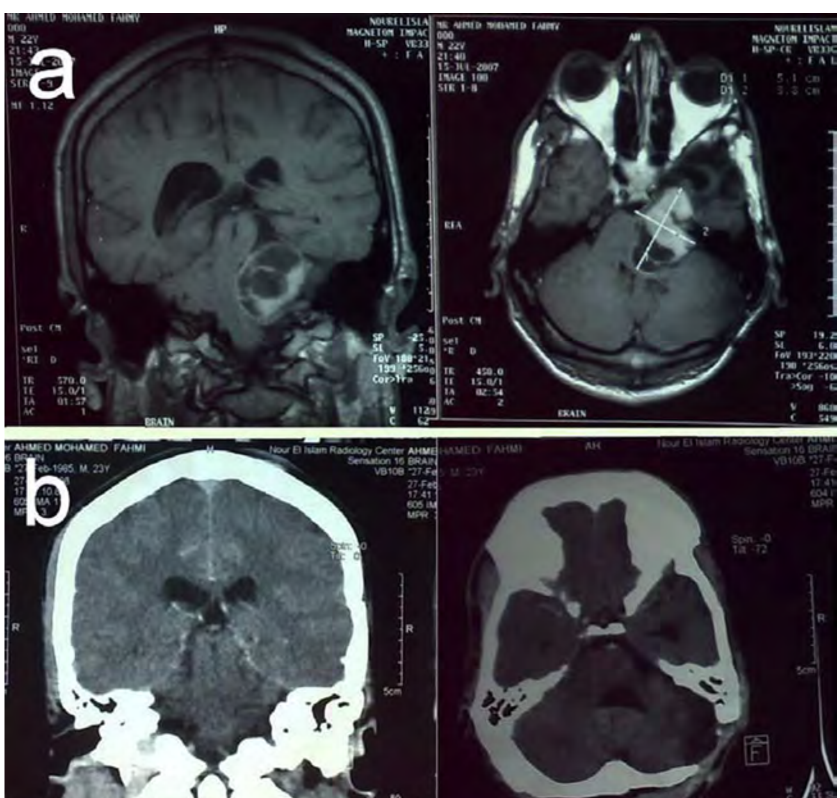

Figure 3 (a) Preoperative MRI showing a left trigeminal schwannoma severely distorting the fourth ventricle and occluding the lower portion of the aqueduct, causing obstructive HC. (b) Post-operative CT although complete restoration of the CSF pathway after tumor excision, patient had a CSF leak and needed shunting.

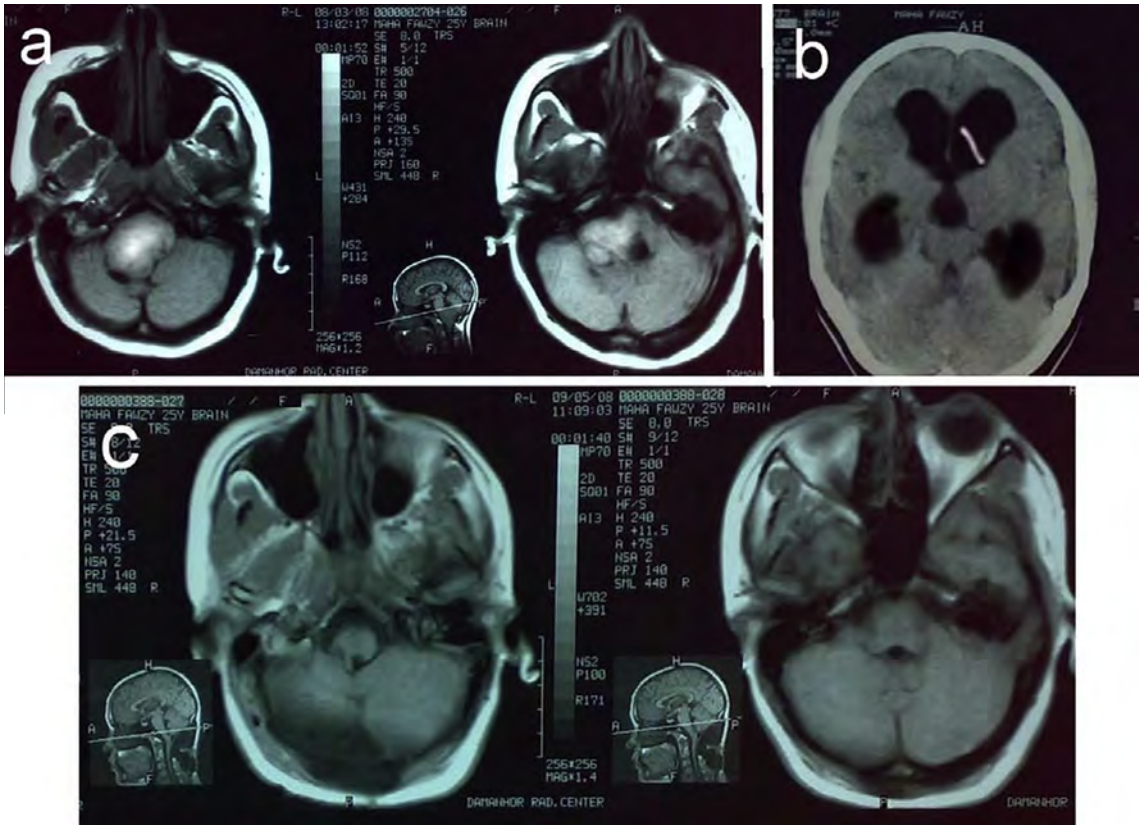

Figure 4 (a) Fourth ventricular choroid plexus papilloma. (b) Postoperatively patient suffered a CSF leak caused by persistent HC seen in CT, needing temporary CSF diversion. (c) Postoperative MRI reveling complete excision of the tumor with patency of the CSF pathway.

Table 1 Histopathological distribution and the need of intraoperative, postoperative or permanent CSF diversion.

	No of cases	Intra-op EVD opening		Cause of post-operative EVD opening						Permanent CSF diversion (V-P Shunt)	
				Persistent HC		Bloody CSF		CSF leak			
		No.	%	No.	%	No.	%	No.	%	No.	%
Ependymoma	14	3	21.43	2	14.29	0	0	1	7.1	3	21.4
Medulloblastoma	16	2	12.5	3	18.75	0	0	1	6.3	4	25
Pilocytic Astrocytoma	3	0	0	0	0	0	0	1	33.3	0	0
Cerebellar metastasis	3	0	0	0	0	2	66.7	0	0	0	0
Tentorial meningioma	2	1	50	0	0	0	0	0	0	0	0
Vestibular and trigeminal Schwannomas	3	2	66.67	0	0	0	0	1	33.3	1	33.3
Choroid plexus papilloma	1	0	0	0	0	0	0	1	100	0	0
TOTAL	42	8	19.05	5	11.9	2	4.8	5	11.9	8	19

permanent CSF shunting, of which seven were midline tumors related to the fourth ventricle (3 ependymoma, and 4 medulloblastoma cases). None of the cases in this series acquired any EVD related infection, nor did those who required subsequent permanent CSF diversion. No cases of tumor seedlings were detected along the EVD pathway.

3.1. Discussion

Hydrocephalus is an important factor influencing the outcome of surgery for posterior fossa tumors. Around 80% of children with posterior fossa tumors are reported to manifest hydrocephalus,[22,23] which persists or progresses in the immediate postoperative period in 25–30% of patients necessitating a diversionary procedure,[24] and with 7–25% needing a permanent shunt.[25,26]

Pre-resection ventricular drainage has a tangible risk of upward herniation ‘reverse coning’, hemorrhage in tumor, seedling or metastasis which lead to concern as regards routine preoperative CSF diversion.[27,28] CSF diversion procedures can disrupt the critical equilibrium maintained between the CSF pathways and the tumor to preserve the diencephalic and brainstem function, thus increasing morbidity and ensuing potential mortality. It has been stated that supratentorial ventriculomegaly associated with an increased CSF pressure, allows the tumor to confine within a specified space.[29,30] Thus intra-operative EVD insertion and keeping it closed till tumor exposure prevents disruption of this equilibrium.

Many authors advocate the use of endoscopic third ventriculostomy (ETV) for posterior fossa tumors presenting with hydrocephalus prior to tumor attack, as it creates a natural by-pass for the ventricular CSF to the subarachnoid space.[31,32] They state that it has the advantage of having a shorter duration of surgery, the lower incidence of morbidity, the absence of mortality, the lower incidence of procedure failure, the significant advantage of not becoming shunt dependent make, and less tendency for blockage which is unpredictable with shunts. Shunt blockage is particularly problematic when the child is having chemotherapy, as leukopenia and thrombocytopenia in the presence of infection make shunt revision impossible.[32]

Cinalli et al. on the other hand reported a complication rate of 13.8% in endoscopic procedures varying form subdural hygroma, subdural empyma, CSF infection, CSF leak, intraventricular hemorrhages, technical failures, thalamic contusion, post-operative transient akinetic mutism, and sudden death as a consequence of closure of the stoma.[33] Morelli et al.[34] reported that 91% of patients (93 patients including patients with severe HC with Evans index [EI] > 0.4 and the mild hydrocephalus with EI between 0.3 and 0.4) had resolution of hydrocephalus, when treated by early posterior fossa surgery with total and subtotal tumor resection and the application of an external drain. In another group ETV success rate for controlling hydrocephalus was 81% of 24 patients but the rate of severe complications related to it was 9%. Concluding that although ETV is an efficient procedure in controlling posterior fossa tumor associated hydrocephalus, yet it is not justifiable to be adopted as a routine preoperative procedure, due to the low rate of persistent hydrocephalus.

ETV has been reported to have a limited success in the treatment of post-hemorrhagic hydrocephalus and communicating hydrocephalus.[35–37] Hydrocephalus is not always caused by obstruction of the CSF pathway; it may be caused by the increase in CSF protein content causing communicating hydrocephalus. This is also believed to be the cause of persistence of HC following tumor removal, in initially obstructive hydrocephalus which is converted into communicating hydrocephalus requiring diversionary procedures other than ETV.[29,38]

Dubey et al. had an incidence of new onset postoperative hydrocephalus for patients after posterior fossa surgery in 4.5%.[39] The development of this de novo hydrocephalus seems to result from other postoperative complications such as edema, hematoma, and CSF infection either by direct obstruction of CSF flow or by impairment of CSF absorption. Intraoperative spillage of blood into the CSF cisterns and subarachnoid space can also cause hydrocephalus due to blood products clogging the arachnoid villi.[40] However, once hydrocephalus has been diagnosed, it is recommended to divert the CSF, in this series opening of the drainage system was done till resolution of the leak and normal CSF flow is regained.

Postoperative hydrocephalus usually presents as headache, nausea/vomiting, gait disturbance, or abducens nerve palsy, or irritability disturbed sensorium. It is important to know that postoperative hydrocephalus may also present as CSF leakage; therefore, it should be suspected in settings of all CSF leaks to enable swift optimal treatment.[41–43] All cases of CSF leak in this series had radiological evidence of hydrocephalus, although complete tumor excision and restoration of the normal CSF pathway, and all leaks were controlled by EVD opening. Only three of the five cases needed permanent CSF diversion surgery in the form of V–P Shunting, to address this communicating hydrocephalus. Dubey et al. in their series of 500 posterior fossa surgeries; cerebrospinal fluid leaks occurred in 13% of patients, cerebellar edema in 5%, hydrocephalus in 4.6% patients, and requiring CSF diversion in some.[39]

Gopalakrishnan et al.[44] had 95.2% of their patients presenting with symptomatic hydrocephalus; 29.8% patients required a CSF diversion procedure in the postoperative period. They reported that the symptom duration had an inverse relation with likelihood of CSF diversion. Midline tumors in comparison to laterally placed lesions are more likely to need diversion especially in certain tumor types (medulloblastoma and ependymoma). Children who underwent intraoperative external ventricular drainage (EVD) had a shunt insertion rate of 39.6% compared with 16.7% of those who did not have an EVD. In contrast to this, in the present study only one of the eight cases that needed intraoperative opening of the EVD needed permanent shunt insertion. While of the twelve cases (28.5%) that needed post-operative opening of the EVD, eight cases (19%) needed permanent shunting and seven of which were midline tumors related to the fourth ventricle (3 ependymoma, and 4 medulloblastoma cases).

Fritsch et al.[45] evaluated CSF diversion procedures (external ventricular drain, VP shunt, or ETV) in pediatric posterior fossa tumors. Forty-six patients (88.5%) did not require a permanent CSF draining procedure. Four patients received a VP shunt and two patients underwent ETV. A temporary EVD was placed in five patients (two required a shunt). They stated that ETV is not indicated as a standard operation either prior to or following tumor removal. Bognar et al.[22] stated that it is not justifiable to do preoperative third ventriculostomy due to the low postoperative shunt insertion rate in their series. The fact that less than one-third of patients require a CSF diversion after posterior fossa tumor resection refutes the role of prophylactic preoperative ETV or shunting. Awareness regarding the factors that can predict persistent postoperative hydrocephalus is essential for the surgeon during patient counseling and surgical planning, and also in deciding the intensity of postoperative clinical and radiological monitoring.[44]

Researches have shown that patients who suffer from IVH will be dependent on the shunt system in more than half of the cases.[26,47–51] Another study[46] revealed that up to 30% of IVH cases are resolved without persistence of hydrocephalus, probably due to the dissipation of blood products and associated inflammation from the cerebrospinal fluid with time. In this study, when there was intraventricular extension of the hematoma, the EVD system was left open until the CSF becomes clear of any post-hemorrhagic debris that might cause catheter or valve occlusion. Then the system is closed for a period of two days to radiologically asses the need of permanent shunt.

Omar and Haspani and others emphasized that, the ventricular catheter should be tunneled subgaleally for more than 5 cm, and should not last for more than 10 days to reduce the risk of EVD-related infections.[17–21] These recommendations were implemented in this study without a single case of infection, with the adherence to the use of strict aseptic techniques when handling the EVD.

One cannot extrapolate for the lack of infection in this study that EVD is a safe procedure with a low incidence of infection, but may justify its use in a selected group of patients who present with acute hydrocephalus and GCS < 8, especially in young children with severe preoperative hydrocephalus and a midline tumor where drainage of the hydrocephalus is essential.[52] In cases in which EVD poses a high infection risk, ETV remains an important tool for the management of non communicating hydrocephalus present in these cases. Recently Chin et al. published their study of 48 patients with PFT in which Ommaya reservoir had been used for perioperative EVD, which enabled a total and safe tumor removal, while restoring CSF circulation and providing an effective means of controlling and preventing hydrocephalus secondary to posterior fossa tumors in children.[53] The use of Omaya reservoir seems to reduce the risk of infection met with EVD, but whether this risk is still reduced when continuous drainage is needed, since recurrent tapping poses a risk of infection.

A sudden rise of ICP in a hydrocephalic patient can be fatal and requires prompt treatment of both the hydrocephalus and the causative lesion,[32] which could be accomplished by the technique implemented in this study, while allowing spontaneous resolution of the HC, thus avoiding unnecessary permanent CSF diversion. The timing of CSF diversion whether preoperative or intraoperative, must be individualized for each patient based on his neurological status, patient's age, lesion location and type, and the availability of trained personnel possible to do the definitive surgery, if any delay in the institution of appropriate treatment, preoperative CSF diversion can prevent permanent disability and fatalities.[54–56]

4. Conclusion

Intra-operative insertion of EVD catheter during surgery of posterior fossa tumors, as it allows better control of the ICT during surgery if needed, provides a temporary life saving emergency CSF drainage outlet if tumor resection fails to resolve HC or for the occurrence of de novo HC, since spontaneous resolution of HC may be expected in some cases, and finally it provides adequate control of CSF leak in cases with supratentorial ventriculomegaly, where the use of lumbar drains may be hazardous. Intraoperative drainage prevents possible complications met with early CSF diversion. But the application of this technique should better be restricted to midline posterior fossa tumors related to the ventricular system.

Conflict of interest

There is no conflict of interest to declare.

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