ENDOSCOPIC THIRD VENTRICULOSTOMY: OUTCOME ANALYSIS IN 170 PROCEDURES

Khalid Khanzada[1], Zia Ur Rehman[2]✉

[1] Assistant Professor, Department of Neurosurgery, PGMI, Lady Reading Hospital, Peshawar, Pakistan.

[2]✉ Post Graduate Resident, Neurosurgery Department, PGMI Lady Reading Hospital, Peshawar, Pakistan.

Email: zia127@yahoo.com

Date Submitted: October 20, 2013
Date Revised: February 19, 2014
Date Accepted: February 20, 2014

ABSTRACT

OBJECTIVE: To analyze the outcome of endoscopic third ventriculostomy (ETV) in the management of obstructive hydrocephalus (OHC).

METHODOLOGY: This observational study was conducted at department of neurosurgery, Lady Reading hospital, Peshawar Pakistan from January 2009 to June 2012. During the study period, 130 cases of OHC secondary to posterior fossa tumor undergoing ETV were selected for study through convenient sampling method. The exclusion criteria consisted of patient's age <6 months, previous history of ETV, recurrent tumor, and Kornofsky score <60. Data was collected on a proforma and analyzed by SPSS-16.

RESULTS: Out of 170 patients, 94 (55.3%) were males and 76 (44.7%) were females, ranging in age from 1-45 years. Ninety (52.9%) cases were <5 years of age and 45 cases (26.5%) were in the 6-10 year age group. ETV had successful outcome in 135 (79.4%) patients. Ventriculoperitoneal shunt was required in 14 (8.24%) patients for inadequate ventriculostomy. Ventricular drainage device was inserted in 8 (4.7%) cases for hemorrhagic CSF. Complications were observed in 39 (22.9%) cases including inadequate ventriculostomy (8.24%), ventricular bleed (4.7%), CSF leak (2.4%), asymptomatic pneumocephlus (1.2%), seizures (1.2%) and meningitis (1.2%). Five patients (2.94%) died; 2 (1.2%) each due to reverse conning and ventricular bleed and one (0.6%) due to CSF leak with meningitis.

CONCLUSION: ETV has success rate of 79.4% in OHC with complication rate of 22.9% and mortality rate of 2.94%. Complications can be reduced by proper selection of patients, detailed plan and skilful performance of surgery in experienced hands and meticulous postoperative care.

KEY WORDS: Aqueductal Stenosis, Endoscopic Third Ventriculostomy, Hydrocephalus, Outcome, Pediatric Patient, Tumor.

THIS ARTICLE MAY BE CITED AS: Khanzada K, Rehman Zu. Endoscopic Third Ventriculostomy: Outcome Analysis In 170 Procedures. Khyber Med Univ J 2014; 6(1): 25-30.

INTRODUCTION

Hydrocephalus is the enlargement of cerebral ventricles, which can be caused by blocked circulation of cerebrospinal fluid (CSF). In communicating hydrocephalus the cause of blocked CSF circulation is diminished absorption of CSF in arachnoid granulations, while in non-communicating hydrocephalus the obstruction exists proximally to granulations, for instance stenosis of the aqueduct of Sylvius. Obstruction also occurs in neoplastic diseases – tumors closing the lumen of the fourth ventricle and aqueduct of Sylvius.[1] Endoscopic third ventriculostomy (ETV) is a minimally invasive method of treatment of obstructive hydrocephalus (OHC). The ETV opens the circulation of CSF from the third ventricle to subarachnoid spaces, bypassing the obstructed aqueduct or fourth ventricle. In consequence ETV diminishes the size of the lateral and the third ventricles, thus decreasing the intracranial pressure (ICP). The third ventricle should be sufficiently enlarged to allow safe, limited movement of the endoscope without injury to the lateral walls of the ventricle.[2] In management of hydrocephalus, possible options are ventriculoperitoneal shunts (VPS) or ETV.[3] The advantage of ETV is low risk of long-term complications associated mostly with device malfunction or infections caused by the presence of a foreign object.[4]

ETV has been accepted as the procedure of choice for the treatment of obstructive hydrocephalus (OHC) in children and adults[5], although some controversies persist. The most controversial issue in the application of ETV is whether in children there is a lower age limit at which the treatment could be ineffective.[6] The main debate involving the general population is the outcome vis-à-vis the cause of hydrocephalus. There are reports that support the conflicting notions that outcome after ETV could be a function of previous infection, previous shunt insertion, or primary origin. Finally, the issue of long-term delayed failures of ETV is also debated.[7,8]

ETV is a widely accepted treatment for OHC. The procedure was first performed by William Mixter, an urologist in

1923 using an ureteroscope to fenestrate the floor of the third ventricle.[9,10] The advent of valve-regulated shunting technology proved to be an effective method for treating hydrocephalus of multiple causes. Third ventriculostomy remained a stagnant procedure with percutaneous and stereotactic alterations to the procedure requiring more highly specialized techniques and equipment limiting interest in developing the technique. There has been resurgence in interest of applying ETV to broader pathologies as modern endoscopes with their fiber-optics and advanced light sources that allow for excellent resolution of ventricular anatomy and control the safe fenestration of the floor of the third ventricle.[11,12]

OHC caused by anatomic, inflammatory or neoplastic etiology is the most common indication for ventriculostomy.[13] In adults we usually encounter non-communicating hydrocephalus caused by tumors. Thalamic, tectal and pineal tumors are not always amenable to resection, and ETV in conjunction with biopsy of that tumor remains the only possible intervention[14]. Colloid cysts can be resected endoscopically. Lack of effects after shunting or infectious complications associated with VPS may be indications for ETV. Some centers also recommend it in long-standing overt ventriculomegaly (LOVA), Chari malformation and normal pressure hydrocephalus (NPH), although traditionally communicating hydrocephalus has been supposed as a contraindication to ETV. There is evidence that ETV may be successful in some NPH patients. Possible complications of ETV are hypothalamic injury, basilar artery injury, intracerebral, intraventricular or subdural hemorrhage, CSF leakage, CNS infection, subdural hygroma or hematoma, epilepsy, and headache due to collection of air subdurally over the frontal cortex, with an overall complication rate of 8.5%.[15]

ETV is being practiced in Pakistan and the results are encouraging as shown by few local studies published during the last few years.[16-19] In our study we investigated perioperative and intraoperative difficulties, failures and complications based on 130 procedures of ETV conducted in our department in the last 3 and half years.

METHODOLOGY

In this prospective study 130 patients with obstructive hydrocephalus underwent endoscopic 3rd ventriculostomy. These patients were operated in two and a half years' time from January 2011 to June 2013. This study was carried out in Department of Neurosurgery, Govt. PGMI, Lady Reading Hospital, Peshawar, Pakistan. Sampling technique was by non-probability convenient sampling technique. The inclusion criteria were to include all patients with obstructive hydrocephalus, patients of ages more than 6 months, both genders and patients with Kornofsky score above 60. The Exclusion criteria consisted of patient's age less than 6 months, with history of ETV, recurrent tumor based on history and medical records and Kornofsky score below 60. In our unit we adopted the policy of treating severe hydrocephalus in patients with posterior fossa tumor with ETV. The patients were started on steroids on admission. The procedure seems to provide a valid alternative to placement of a permanent shunt in cases in which hydrocephalus develops following posterior fossa surgery.

Data Collection Procedure

This study was considered after approval by the ethical committee of LRH, Peshawar. A complete history of all patients, meeting inclusion criteria was taken and thorough physical examination done at the time of admission in Neurosurgery ward those meeting the inclusion criteria were enrolled in the study through OPD and were admitted in the ward for further workup. Informed written consent was taken from patient or relatives. Exclusion criteria were followed strictly to avoid any bias or confounding factors in our results. All the surgeries were performed by single experienced neurosurgeon having minimum of 3 years of experience. The collected information was entered in Statistical Package of Social Sciences (SPSS) version 10 and for analysis. Frequency and percentage were calculated for categorical variables like gender and post-operative outcome. All results are presented as graphs and tables.

Endoscopic Third Ventriculostomy Surgical Technique:

The ETV procedure begins from the skin incision usually in the right frontal area and burr hole 2-3 cm lateral to the midline, 1-2 cm anterior to the coronary suture. A rigid endoscope is passed through the frontal lobe into the lateral ventricle, then through the foramen of Monro to the floor of the third ventricle which is formed by the terminal membrane containing the Liliequist membrane. The goal of the procedure is to make a hole in this membrane anterior to the mammillary bodies and posterior to the infundibular recess. The opening in the membrane is made using a Fogarty catheter no. 2 or 3, or by another rigid instrument to puncture the floor of the ventricle, then the balloon serves for enlargement of the perforation.

Endoscopic visualization enables inspection of structures behind the membrane such as basilar and posterior cerebral arteries. Frequently fast, vibrant flow of CSF through the stoma can be seen. Successful perforation is determined by many factors, including anatomical factors such as narrowed foramen of Monro with oversized choroid plexus lying in the posterior part of the foramen, small triangle made by mammillary bodies and infundibular recess which is the target of perforation, and thick, opaque membrane of the bottom of the third ventricle, which should be perforated. Visualization during the procedure can be worsened by bleeding. Meticulous hemostasis can be achieved by microcoagulation, or long-lasting, excessive washing with warm Ringer solution. Bloody or blurry CSF requires washing, which improves transparency and prevents complications such as thalamus injury, forniceal columns injury, or basilar artery injury. In order to decrease the risk

of perioperative complications magnetic resonance imaging (MRI) is necessary and especially mid-sagittal images enabling optimal localization of the burr hole. It is possible to use neuronavigation to select the most appropriate trajectory from the entry point on the skull to the floor of the third ventricle to avoid straining of the foramen Monro and find the safest, straight way with proper visualization of all structures in the floor.

RESULTS

Out of 170 patients, 94 (55.3%) were males and 76 (44.7%) were females, M/F ratio=1.23; ranging in age from 1-45 years. Ninety (52.9%) cases of OHC were <5 years of age and 45 cases (26.5%) were in the 6-10 year age group, 22 cases (12.94%) occurred in 11-14 years and 13 cases (7.65%) in age group >14 yrs. The common causes of OHC were posterior fossa tumours in 76 cases (44.7%) and acqueductal stenosis in 44 (25.9%) cases (figure 1).

ETV had successful outcome in 135 (79.4%) patients. Ventriculoperitoneal shunt (VPS) was required in 14 (8.24%) patients for inadequate ventriculostomy. Ventricular drainage device (VDD) was inserted in 8 (4.7%) cases for hemorrhagic CSF. In 13 (7.64%) patients, ETV and tumor biopsy were performed.

The signs and symptoms of increased intracranial pressure (ICP) resolved after ETV in all patients. Overall complications rate was 22.9% (n=39) as given in figure 2. Commonest complication was inadequate ventriculostomy (8.24%). Follow-up brain CT scan showed complications related to third ventriculostomy like ventricular bleed in 8 (4.7%) cases & asymptomatic pneumocephlus in 2 (1.2%) cases. The common post-operative complications observed were CSF leak in 4 (2.4%) cases, followed by seizures in 2 (1.2%) cases and meningitis 2 (1.2%) cases. All the patients with complication were treated conservatively.

Five patients (2.94%) died; 2 (1.2%) due to reverse conning, 2 (1.2%) due to ventricular bleed and one (0.6%) due to CSF leak with meningitis. Figure 3 shows pre-operative and post-operative CT scans in patients having ETV for OHC.

The patients were sent home after ETV/VP shunt on 3rd post-operative day and were asked to come after 4 weeks for definitive surgery in cases of obstructive hydrocephalus secondary to tumors. Follow-up CT brain was performed showing reduction in ventricular size and resolution of signs of increased ICP in all patients after 4 weeks. Those patients with EVD/no drainage procedure performed were subjected to tumor surgery on next available list. The definitive surgery showed satisfactory condition in relation to the CSF pressure, even cases which showed some tightness in brain the routine measures were adequate to control the pressure, especially after the cistern was opened and more CSF released.

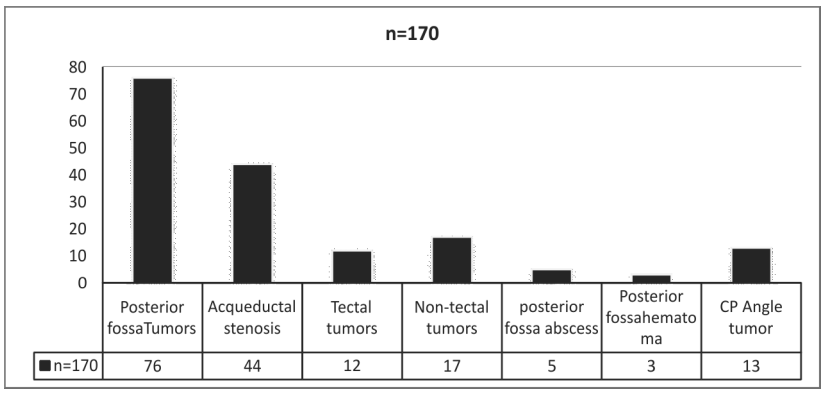

Figure 1: Etiology of Obstructive Hydrocephalus

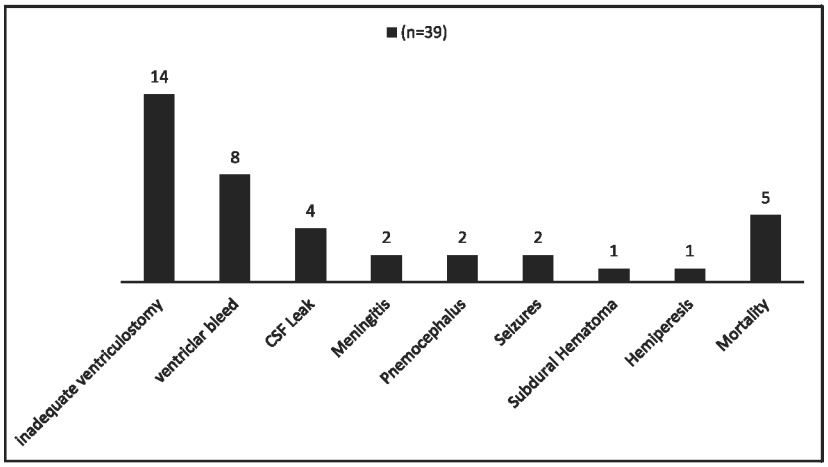

Figure 2: Complications of Endoscopic Third Ventriculostomy

DISCUSSION

ETV is performed in patients with non-communicating hydrocephalus caused by obstruction existing distal to the third ventricle in order to bypass disturbed flow of CSF, which leads to the lowering of ICP. In our neurosurgical practice we very rarely deal with patients having congenital aqueductal stenosis. Frequently we can suspect obstruction based on a picture of triventricular hydrocephalus and cine-MRI scans demonstrating the flow void phenomenon.[9] Most often we treat patients with tumors obstructing proper flow of CSF. In cases of non-operable tumors, it is the only intervention we conduct. In 13 (7.64%) cases it was possible to combine ETV with biopsy of the tumor, but usually biopsy worsens the conditions of ETV because it causes bleeding which needs irrigation. All patients with triventricular hydrocephalus with sufficient dilatation of the third ventricle are amenable to ETV.

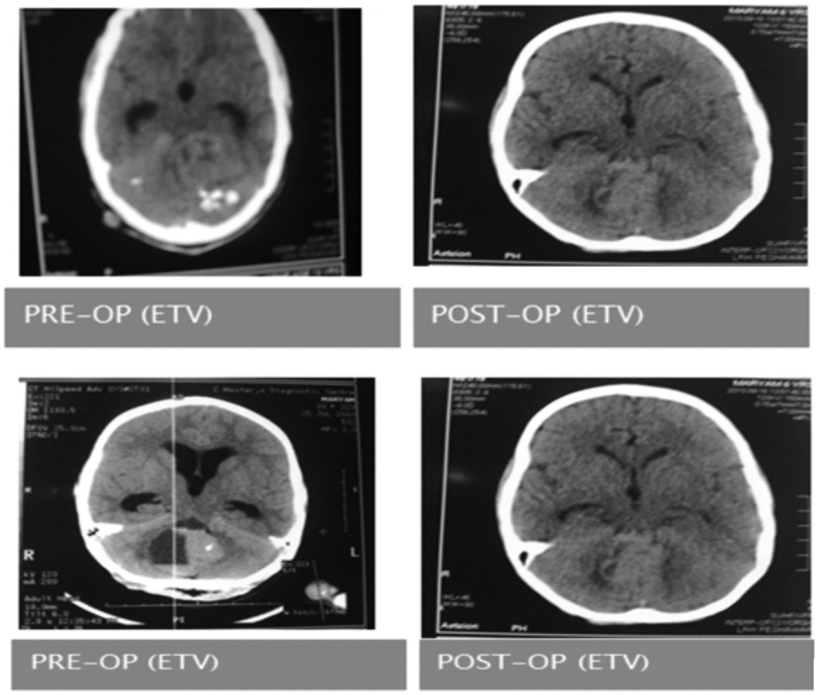

Figure 3: Pre And Post-Operative CT Scans In Patients Having Endoscopic Third Ventriculostomy (ETV) For Obstructive Hydrocephalus

The ETV is a minimally invasive procedure, is safe and is especially effective and useful in non-communicating HCP.[20,21] Alleviation or diminishment of symptoms associated with increased ICP occurred in patients with idiopathic stenosis of the aqueduct in 44 cases in our group, and obstructive HCP caused by tumor in 76 cases. It is important to select patients for ETV. Patients with a history of ventricular hemorrhage, meningitis and leptomeningeal metastasis should be excluded for consideration of ETV because of concern for decreased CSF resorption capacity. Patients with headache associated with nausea, vomiting, or lethargy were more likely to respond to treatment with ETV relative to patients presenting with headache only.[22]

In our study, ETV was performed successfully with good outcome in 135/170 (79%) patients with obstructive hydrocephalus There was no permanent morbidity relate to ETV. The success rate of ETV in adults depends on the etiology of HCP and is calculated as 68% to 83%.[19, 23,24] In our group we estimate the initial success rate as around 79.4% which is supporting other local studies showing success rate of 71%[19], 78.4%[17] and 83.07%.[18] The success rate is also comparable with that of Hopf et al, have reported a success rate of 76% for ETV in severe hydrocephalus secondary to posterior fossa tumor,.[9] Similarly Valenzuela S, et al also reported a 76% success rate for ETV in severe hydrocephalus before posterior fossa tumor surgery.[25]

In our study, the results show that the number of patients requiring VP-Shunt was reduced to 8.24% which is comparable to previous local figures of 7.69%[18] & 4.5%.[19]As reported by Saint-Rose in his study this number may be reduced to 6% if an ETV is performed as the first CSF diversion technique or in combination with a ventriculostomy.[15]

The long-term rate is much lower due to progression of neoplastic disease or re-closure of the stoma. The ETV is a relatively safe procedure in experienced hands but carries the risk of complications such as hypothalamic or thalamic injury[26]. The technique can be augmented by the use of neuronavigation or stereotactic guidance[27]. The most common difficulties associated with the surgery are narrow space between mammillary bodies and dorsum sellae, high localization of basal artery bifurcation, and opaque floor of the third ventricle bulging to the sellae[27].

Mortality rate in our study was 2.94% which is comparable to 1.93% by Ali M. et al.[19] Out of 5 patients (2.94%) died, 2 (1.2%) died due to reverse conning, 2 (1.2%) due to ventricular bleed and one (0.6%) due to CSF leak with meningitis. The results of our study are comparable with that of Sainte-Rose et al[14]. Sainte-Rose et al[14], reviewed 67 ETVs performed before tumor removal in patients with severe hydrocephalus. In this series there were no deaths and no permanent morbidity related to the procedure, a 98.5% rate of immediate symptomatic resolution, and a 94% rate of shunt-free patients after tumor removal. Preoperative normalization of CSF hydrodynamics seems to decrease the risk of permanent postoperative impairment of CSF circulation. However, by performing an ETV in every child with obstructive hydrocephalus and tumor, one would be exposing 70% of children to the morbidity of an extra surgical procedure[24]. Riva-Cambrin R et al[28] have developed a pre-operative clinical grading system to establish the need for post-operative CSF diversion. This grading system is based on age (<2 years), initial degree of hydrocephalus, tumor histological features, and presence of metastasis to predict probability of hydrocephalus at 6 months. This system may help the surgeon in deciding whether to perform CSF diversion (shunt or ETV) prior to surgical removal of tumor.[26]

The overall complications related to ETV in our study were 22.9% with two cases of deleterious sequela like upward herniation. Common complications were ventricular bleed (4.7%), CSF leak (2.4%), asymptomatic pneumocephlus (1.2%), seizures (1.2%) and meningitis (1.2%).

According to Bouras T et al[29], who conducted a review on complications of ETV, the overall complication rate was 8.8%. Permanent morbidity was

2.1%, neurologic in 1.2% (hemiparesis, gaze palsy, memory disorders, and/or altered consciousness), hypothalamic in 0.9%. Intraoperative hemorrhage was present in 3.9%, severe in 0.6. Other surgical complications occurred in 1.13% including thalamic infarcts, subdural, intracerebral, and epidural hematomas. Cerebrospinal fluid infections occurred in 1.8%, CSF leak in 1.7%, anesthetic complications (bradycardia and hypotension) in 0.19% of cases. Schmid UD, et al showed that there is considerable morbidity when compared with EVD for <5 days with a very low complication rate (2.2%), reported 10% rate of upward herniation in cases of posterior fossa tumors subjected to preliminary shunting, and spreading of medulloblastomas through ventriculo-peritoneal shunts.[30] These arguments and the improvements in the availability and type of neuroimaging systems that permit earlier diagnosis have caused neurosurgeons to question the need for routine shunt placement.

Our study shows upward herniation in 1.2% and hemorrhage in 4.7% patients in which EVD was performed. The patients were having normal ICP with no pseudomeningocele formation and pseudobulbar palsy except CSF leak, observed in 2.4% patients. In comparison with the study conducted by Rappaport ZH, et al[31] and Shalit MN, et al[32] on external ventricular drainage used in these situations reported 10% and 4.9% infection rate respectively and upward herniation or haemorrhage. Seventeen to 40% of patients treated with this protocol have uncontrolled hydrocephalus after tumor removal and require placement of a definitive CSF shunt. This kind of hydrocephalus occurs predominantly within the first month of surgery. These patients, placed at risk of suffering ICH, have an increased rate of CSF leakage and pseudomeningocele formation, a prolonged hospitalization and a high risk of pseudobulbar palsy.

CONCLUSION

Based on our study we conclude that ETV is a useful and helpful procedure in non-communicating HCP. ETV has success rate of 79.4% in OHC with complication rate of 22.9% and mortality rate of 2.94%. The most common age group involved was under 5 years. Per-operative ventricular bleeding was the most common complication followed by CSF Leak post-operatively. Complications can be reduced by proper selection of patients, detailed plan and skillful performance of surgery in experienced hands and meticulous postoperative care.

REFERENCES

1. Bognar L, Borgulya G, Benke P, Madarassy G: Analysis of CSF shunting procedure requirement in children with posterior fossa tumors. Childs Nerv Syst 2003, 19: 332-336.
2. Dubey A, Sung WS, Shaya M, Patwardhan R, Willis B, Smith D, Nanda A. Complications of posterior cranial fossa surgery — an institutional experience of 500 patients. Surgical Neurology 2009; 72: 369-75.
3. De-Bont JM, Packer RJ, Michiels EM, Den-Boer ML, Pieters R. Biological background of pediatric medulloblastoma and ependymoma: A review from a translational research perspective. Neuro Oncol 2008; 10(6): 1040-60.
4. Karajannis M, Allen JC, Newcomb EW. Treatment of Pediatric Brain Tumors. J Cell Physiol 2008; 217(3): 584-89.
5. Rieken S, Gaiser T, Mohr A, Welzel T, Witt O, Kulozik AE et al. Outcome and prognostic factors of desmoplastic medulloblastoma treated within a multidisciplinary treatment concept. BMC Cancer 2010; 10: 450.
6. Hafez RFA. Stereotaxic gamma knife surgery in treatment of critically located pilocytic astrocytoma: preliminary result. World Journal of Surgical Oncology 2007; 5: 39.
7. Hoff KV, Kieffer V, Habrand JL, Kalifa C, Dellatolas G, Grill J. Impairment of intellectual functions after surgery and posterior fossa irradiation in children with ependymoma is related to age and neurologic complications. BMC Cancer 2008; 8: 15.
8. Song DK, Lonser RR. Pathological satiety caused by brainstem hemangioblastoma. J Neurosurg Pediatr. 2008; 2(6): 397-401.
9. Hopf NJ, Grunert P, Fries G. Endoscopic third ventriculostomy: outcome analysis of 100 consecutive procedures. Neurosurg 1999, 44(4): 795-804; Discussion 804-806.
10. Lee M, Wisoff JH, Abbott R: Management of hydrocephalus in children with medulloblastomas: prognostic factors for shunting. Pediatr Neurosurg 1994, 20(4): 240-247.
11. Valenzuela S, Trellez A: Pediatric neuroendoscopy in Chile: Analysis of the first 100 cases. Childs Nerv Syst 1999, 15(9): 457-460.
12. Cinalli G: Alternatives to shunting. Childs Nerv Syst 1999, 15: 718-731.
13. Chumas P, Saint-Rose C, Cinalli GI: III ventriculostomy in the management of posterior fossa tumors in children. Proceedings of the ISPN congress, Santiago, Chile, 26-29 September 1995. Childs Nerv Syst 1995, 11: 540.
14. Sainte-Rose C, Cinalli G, Roux FE: Management of hydrocephalus in pediatric patients with posterior fossa tumors: the role of endoscopic third ventriculostomy. J Neurosurg 2001, 95(5): 791-797.
15. Culley DJ, Berger MS, Shaw D, Geyer R: An analysis of factors determining the need for ventriculoperitoneal shunts after posterior fossa tumor surgery in children. Neurosurg 1994, 34(3): 402-7; Discussion 407-8.
16. Brohi SR, Brohi AR, Sidiqui MA, Mughal SA, Saeed S. Outcome of endoscopic third ventriculostomy in hydrocephalus. J Surg Pak (Inter) 2010; 15(1): 25-8.
17. Haq MIU, Khan SA, Raja RA, Ahmed E. Efficacy of endoscopic third ventriculostomy in noncommunicating hydrocephalus. J Ayub Med Coll Abbottabad 2012; 24(2): 144-6.
18. Rehman ZU, Khanzada K, Husain R, Ali M, Ali M. Experience with endoscopic third ventriculostomy in the management of hydrocephalus secondary to posterior fossa tumor. J Postgrad Med Inst 2013; 27(4): 433-8.
19. Ali M, Usman M, Khan Z, Khan KM, Hussain R, Khanzada K. Endoscopic third ventriculostomy for obstructive hydrocephalus. J Coll Physicians Surg Pak 2013; 23 (5): 338-41.
20. Epstein F, Murali R: Pediatric posterior fossa tumors: hazards of the "preoperative" shunt. Neurosurg 1978, 3(3): 348-350.
21. Fiorillo A, Maggi G, Martone Al: Shunt-related abdominal metastases in an infant with medulloblastoma: long-term remission by systemic chemotherapy and surgery. J Neurooncol 2001, 52(3): 273-6.
22. Gruss P, Gaab M, Knobloch OE: Disorders of CSF circulation after interventions in

the area of the posterior cranial fossa with prior shunt operation. Adv Neurosurg 1978, 5: 199-202.

23. McLaurin RL: Disadvantages of the preoperative shunt in posterior fossa tumors. Clin Neurosurg 1983, 30: 286-292.

24. Muszynski CA, Laurent JP, Cheek WR: Effects of ventricular drainage and dural closure on cerebrospinal fluid leaks after posterior fossa tumor surgery. Pediatr Neurosurg 1994, 21: 227-231.

25. Valenzuela S, Trellez A. Pediatric neuroendoscopy in Chile. Analysis of the first 100 cases. Childs Nerv Syst 1999; 15: 457-460.

26. Papo I, Caruselli G, Luongo A: External ventricular drainage in the management of posterior fossa tumors in children and adolescents. Neurosurg 1982, 10(1): 13-15.

27. Taylor WAS, Todd NV, Leighton SEJ: CSF drainage in patients with posterior fossa tumours. Acta Neurochir (Wien) 1992, 117: 1-6.

28. Riva-Cambrin R, Detsky AS, Lamberti-Pasculli M, Sargent MA, Armstrong D, Moineddin R, et al.: Predicting postresection hydrocephalus in pediatric patients with posterior fossa tumors. J Neurosurg Pediatr 2009; 3 (5):378-85.

29. Bouras T1, Sgouros S. Complications of endoscopic third ventriculostomy. J Neurosurg Pediatr 2011; 7(6): 643-9.

30. Schmid UD, Seiler RW: Management of obstructive hydrocephalus secondary to posterior fossa tumors by steroids and subcutaneous ventricular catheter reservoir. J Neurosurg 1986, 65(5): 649-653.

31. Rappaport ZH, Shalit MN: Perioperative external ventricular drainage in obstructive hydrocephalus secondary to infratentorial brain tumours. Acta Neurochir (Wien) 1989, 96: 118-121.

32. Shalit MN, Ben Ari Y, Eynan N: The management of obstructive hydrocephalus by the use of external continuous ventricular drainage. Acta Neurochir (Wien) 1979, 47: 161-172.

AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

KK: Conception and design, acquisition and analysis of data, critical revision, final approval of the version to be published

ZUR: acquisition of data, drafting the manuscript, final approval of the version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Author declares no conflict of interest

GRANT SUPPORT AND FINANCIAL DISCLOSURE

NIL

KMUJ web address: www.kmuj.kmu.edu.pk

Email address: kmuj@kmu.edu.pk