Open Access
Original Article

Intraoperative Neurophysiological Monitoring During Resection of Posterior Fossa Lesions

Memoona Ejaz, Habibullah Khan, Junaid Mushtaq, Kaleem Safdar, Khurshid Ali Bangash, Umer Farooq, Ahmed Tashfeen, Ali Ahmed, Zeeshan Ahmed, Asif Rasheed, Fasih Hashmi*

Combined Military Hospital/National University of Medical Sciences (NUMS) Rawalpindi Pakistan, *Ilama Iqbal Open University, Islamabad, Pakistan

ABSTRACT

Objective: To study the benefits of intraoperative neurophysiological monitoring during the resection of posterior fossa lesions.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Neurosurgery, Combined Military Hospital (CMH), Rawalpindi Pakistan, from Apr 2020 to Mar 2022.

Methodology: One hundred and sixty-nine diagnosed posterior fossa lesions, including cerebellopontine angle tumours, were included. The chi-square test was used to test the association of new neurological deficits among different pathologies. In addition, the sensitivity and specificity of IONM were also calculated for risk identification of new neurological deficits.

Results: The mean age of the patients was 35.75±9.31 years. No clinical signs and symptoms were associated with the new neurological deficit (p-value> 0.05). The majority (72.8%) of the surgeries were declared successful, as only 46(27.2%) surgery outcome was "Poor". The sensitivity of the IONM monitoring was 51.61%, specificity 68.42%, positive predictive value 66.67% and negative predictive value 53.61%.

Conclusion: Intraoperative neuro-monitoring plays a vital role in obtaining successful results in posterior fossa surgeries because the prevalence of neurological deficits in the posterior fossa lesions was very high compared to the other surgeries.

Keywords: Electroencephalogram (EEG), Electromyography (EMG), Intraoperative neuro-monitoring (IONM), Posterior fossa lesion surgeries, Somatosensory evoked potential, Transcranial motor evoked potentials (tcMEPs).

How to Cite This Article: *Ejaz M, Khan H, Mushtaq J, Safdar K, Bangash KA, Farooq U, Tashfeen A, Ahmed A, Ahmed Z, Rasheed A, Hashmi F. Intraoperative Neurophysiological Monitoring During Resection of Posterior Fossa Lesions. Pak Armed Forces Med J 2023; 73(2): 489-493.*
DOI: https://doi.org/10.51253/pafmj.v73i2.9089

INTRODUCTION

Posterior fossa lesion is considered one of the most devastating types of illness. The posterior fossa has a narrow space and accommodates vital brain stem structures. These tumours are much more prevalent in children as compared to adult human beings. An extensive review conducted at the Children's Hospital of Australia identified that the most common type of tumour was pilocytic astrocytoma 29%, followed by medulloblastoma 12% and ependymoma 6%.[1] The most common lesion at the cerebellopontine angle is vestibular schwannoma, followed by meningiomas, more prevalent in the adult population.[2,3]

Most of the tumours in the posterior fossa are identified with contrast-enhanced imaging because, in some cases, it is impossible to identify the tumour with plain computed tomography (CT) or magnetic resonance imaging (MRI). In some cases, for differential diagnosis, and in particular cases, radioisotope studies are used to reflect the functional status of tumours and their characteristics.[4,5]

Correspondence: Dr Habibullah Khan, Department of Neurosurgery, Combined Military Hospital Rawalpindi-Pakistan
Received: 27 Jul 2022; revision received: 15 Dec 2022; accepted: 22 Dec 2022

IONM is used to identify and prevent neurological risks during various surgeries. It is the gold standard of care for many surgical services. The surgeon may apply changes in the procedures according to the neurologic status of the patient being monitored through IONM to decrease the risk of paralysis6 and facial nerve palsy in cerebellopontine angle tumours.[6,7] Various IONM modalities are used for monitoring, i.e. Somatosensory Evoked Potentials (SSEP), Motor Evoked Potentials (MEP), Spontaneous and Triggered Electromyography (EMG), Brainstem Auditory Evoked Potentials (BAEPs).[7] An alert of SSEP indicates an increase in latency of more than 10% and/or a decrease in more than 50% amplitude.

MEPs help in protecting the corticospinal tracts during brain, brainstem, and spine surgeries. Intraoperative MEP can be elicited by transcortical (TCeMEP) or direct cortical electrical stimulation (DECS) of the brain.[8]

It is not easy to monitor highly complex functions performed by the brain just by the measurement of sensation and motor pathways developed for the monitoring of the spinal cord.[9,10] Various functions, such as vision, speaking, hearing, and functions performed by cranial nerve, are highly complex and demand specialised techniques and equipment for analysis. This study was conducted to look for the benefits of intraoperative neurophysiological monitoring during the resection of posterior fossa lesions.

METHODOLOGY

The cross-sectional study was conducted at the Department of Neurosurgery, Combined Military Hospital (CMH) Rawalpindi, from April 2020 to March 2022, after approval from the Institutional Ethical Review Committee (No.36-02-20). The sample size of the study was calculated by a sample size calculator for sensitivity and specificity by taking population proportion of neurological deficit of 0.44, a sensitivity of 95% and specificity of 77%.[11]

Inclusion Criteria: Patients of either gender, having no history of any other neurological disease, who presented with signs and symptoms suggestive of post fossa tumour, were included in our study.

Exclusion criteria: Patients previously operated on with a tumour recurrence and tumours arising from the brain stem were excluded from this study.

We included 169 diagnosed cases of posterior fossa lesions necessary for surgery. Non-probability consecutive sampling technique was used to enrol the patients in the study. The patients were assessed clinically by a consultant neurosurgeon from the operating team. Lesions of all the included patients were further confirmed by magnetic resonance imaging. After the pre-operative assessment, informed and written consent was taken from all patients/attendants.

During surgery, the patients were prone to posterior lesions and semi-prone to cerebellopontine angle (CPA) tumours with support for the thorax, pelvis, and legs. In patients with posterior lesions, a midline skin incision was made. The spinous process of C2 was not exposed to retain its ligamentous and muscular attachment. , a sub-occipital craniectomy was performed. A "Y" shaped dural opening was performed. In addition, for CPA tumors reterosigmoid sub-occipital craniotomy was done in standard fashion. In order to perform neuromonitoring, a standardised institutional set-up was adopted, which includes facial nerve monitoring SEP, and MEP recordings from the median and tibial nerves, as well as those from the corticobulbar muscles in the upper and lower extremities. Modalities serving as controls were repeated whenever variations were found to rule out general effects. Surgeons were alerted to major changes in neuromonitoring by the above-described warning indications. Surgeons re-evaluated current surgical procedures in response to changes in the IOM. Urgent action was taken, such as warm saline irrigation, raising blood pressure, administering Papaverine or Nimodipine and pausing resection. All set-ups followed international standards.

Bolus dosages of Propofol (1.5mg/kg)/ Remifentanil (1mg/kg) and the medium-acting muscle relaxant Rocuronium were used to induce anaesthesia (50 mg bolus). In addition, Propofol (3–6 mg/kg/hr) and Remifentanil (0.2–0.3 mg/kg/min) were used to keep the patient asleep.

The intraoperative neurological injury was also observed along with the neurophysiologic technique. After completion of the surgery, outcomes were noted in 3 categories excellent, good, and poor. The patients have no neurological deficit defined as “excellent”. Subtotal excision with no or reversible neurological deficit was considered a “good” outcome, whereas irreversible neurological deficit was considered a “poor” outcome. Patients were followed up for the next six months after surgery, and complications along with final observation regarding neurological deficit were noted down.

Statistical Package for Social Sciences (SPSS) version 23.0 was used for the data analysis. A sensitivity specificity analysis was made to find the diagnostic accuracy of identifying neurological deficits through intraoperative IOM findings. The Chi-square test was used to test the association of IOM findings with the surgical outcome and post-operative neuro-logical deficit after six months of follow-up. The p-value of ≤0.05 was considered significant.

RESULTS

One hundred sixty-nine patients were included in the study, and the mean age was 35.75±9.31 years ranging from 4 to 60 years. The mean age of male and female patients was not significantly different between male and female patients, with a p-value of 0.616. The association of signs and symptoms of clinical presentation at admission with the post-operative new neurological deficit was mentioned in Table-I. To assess the intraoperative neurological change, different neurophysiologic techniques were used. The frequency distribution of different neurophysiologic techniques is shown in Table-II. IONM identified neurological deficits in 72(42.6%) cases. The result showed that only 10% of cases had no complications after surgery. The most common complication was cerebrospinal fluid leakage which was 25(14.8%). The descriptive analysis of post-op complications is shown in Table-III.

Table-I: Association of Clinical Sign and Symptoms with occurrence of New Neurological Deficit (n=169)

Clinical Symptoms	Categories	New Neurological Deficit		*p*-value
		Yes	No	
Headache	Yes	84(54.2%)	71(45.8%)	0.467
	No	9(64.3%)	5(35.7%)	
Vomiting	Yes	67(51.1%)	64(48.9%)	0.059
	No	26(68.4%)	12(31.6%)	
Ataxia	Yes	19(50%)	19(50%)	0.479
	No	74(56.5%)	57(43.5%)	
Cranial Nerve Palsy	Yes	17(54.8%)	14(45.2%)	0.981
	No	76(55.1%)	62(44.9%)	

Table-II: Frequency Distribution of Neurological Technique used in Intraoperative Neurophysiological Monitoring (IONM) (n=169)

Neurological Techniques	n(%)
Electroencephologram (EEG)	39(23.1%)
Samatosensory Evoked Potentials (SSEPs)	37(21.9%)
Electromyography (EMG)	40(23.7%)
Transcranial Motor Evoked Potentials (tcMEPs)	53(31.4%)

A study in Egypt included 44 patients aged between 2-30 years. At the end of the surgery, the outcome was noted down in 3 categories Excellent, Good and Poor. The study showed that 27.3% were excellent, 50% were good, and 22.7% of surgeries showed poor results12. The surgery for posterior fossa lesions was risky, and neurophysiological deficits were observed in higher in children. In this study, the cases included children and young; hence, we do not give any verdict about successive surgery for young/adults.

In a local study conducted in 2021 in Lahore, the researchers included 80 cases. Among them, 57% were female, and the range of age of the overall patients included in the study was from 6-30 years. The study result showed that Medulloblastomas were the most common tumour pathology, 31%, followed by Ependymomas and Pilocytic astrocytoma, 26% and 24%, respectively, in the sample. The successive rate of surgery, based on gross total resection, against the posterior fossa tumour, was 90%. The best results were obtained against pilocytic astrocytoma followed by Ependymomas.[13] In another local study, researchers included 71 cases of posterior fossa tumour surgery, of which 70.4% were male. A satisfactory surgical outcome was found in 80.3% of cases.

Table-III: Complication of the Surgery with respect of Tumor Pathology (n=169)

Complications	Tumor Pathology				
	Vestibular Schwannoma	Astrocytoma	Ependymoma	Metastatic	Medulloblastoma
None	8 (12.5%)	7 (14.89%)	1 (2.56%)	1(6.67%)	0 (0%)
Shunt obstruction	8 (12.5%)	6 (12.7%)	5 (12.8%)	2(13.3%)	1 (25%)
Hemorrhage	8 (12.5%)	4(8.51%)	8 (20.5%)	1(6.67%)	0 (0%)
Cerebrospinal fluid leakage	13 (20.3%)	3 (6.38%)	8 (20.5%)	1(6.67%)	0 (0%)
Wound Infection	8 (12.5%)	5 (10.63%)	4 (10.2%)	3(20%)	0 (0%)
Cranial Nerve Palsy	9 (14.06)	17.0%)	5 (12.8%)	2(13.3%)	0 (0%)
Mutism	3 (0.04%)	5 (10.63%)	5 (12.8%)	5(33.3%)	1 (25%)
Seizures	7 (10.9%)	9 (19.14%)	3(7.69%)	0(0%)	2 (50%)

Most surgeries were declared successful, as only 46(27.2%) surgery outcome was "Poor". Few complications are commonly observed irrespective of the surgery outcome, as only 17(10.1%) cases were without complications at the end of the follow-up. The detailed comparison between the IONM result and surgery outcome and the final result of neurological deficit after six months of follow-up is mentioned in Table-IV. The diagnostic accuracy of IONM was also calculated. The sensitivity of the IONM monitoring was 51.61%, specificity 68.42%, positive predictive value 66.67% and negative predictive value 53.61%.

DISCUSSION

Multiple kinds of research have highlighted the posterior fossa lesion surgery, its complications and monitoring differently, i.e., short-term and long-term deficits. In addition, the studies are different for the follow-up time and the patients' age.[12]

Table-IV: Association of IONM findings with Surgery Outcome and Neurological Deficit observed at the end of study (n=169)

Variables	Categories	Intraoperative Identification of Neurological deficit through IONM		*p*-value
		No	Yes	
Surgery Outcome	Excellent	40(23.6%)	7 (4.14%)	<0.001
	Good	47(27.8%)	29(17.15%)	
	Poor	10(5.91%)	36(21.3%)	
Post-op New Neurological Deficit	No	52(30.7%)	24 (14.2%)	0.009
	Yes	45(26.6%)	48(28.4%)	

It was discussed that patients with papilledema, hemiparesis, and meningismus have comparatively low successive results in surgery with p value 0.011, 0.005 and 0.043, respectively.[14]

On a national level, an American study included 17,610 patients; the male-to-female ratio was 1:3.5. IONM monitoring was necessarily used in 63.9% of cases. The significance of IONM monitoring was shown through the percentage of Recurrent Laryngeal Nerve (RLN) injury, which was less than 5.7% in cases where IONM monitoring was done as compared to 6.8% where IONM monitoring was not done with p value 0.0001.[15] In a recent study conducted in Qatar, researchers included 62 patients, and IONM monitoring was sued in all surgeries. Out of 62, only two patients' neuro tonic EMG were discharged. Among them, one of the brain tumour surgery and the second one was the right acetabular hip surgery with post-operative right foot drop.[16]

Ishida *et al*. reported that baseline characteristics were not associated with the outcome of the surgery. IONM findings and tumour pathology were associated with new neurological deficits post-operatively within six months. The result showed that IONM has a sensitivity of 82.4%, specificity of 90.7%, positive predictive value (PPV) of 63.6%, and negative predictive value (NPV) of 96.3% to predict the new neurological deficit.[17] The sensitivity and specificity of IONM may increase when a certified technologist having Certification in Intraoperative Neurophysiological Monitoring (CNIM), Board-Certified Neurophysiologist (DABNM) or Neurologist (ABCN-IONM), working in the team as the certified technologist gives better and satisfactory results as compared to the non-certified teams.[18-19]

LIMITATIONS

Brain stem auditory evoked potentials also need to be monitored during the resection of posterior fossa lesions, especially those at the cerebellopontine angle, as vestibular schwannomas need special attention to hearing impairment if the serviceable hearing is present preoperatively.

CONCLUSION

Intraoperative neuro-monitoring plays a vital role in obtaining successful results in posterior fossa surgeries due to the high risk of neurological deficits caused by injury to vital structures lying closely in the very small space of the posterior fossa.

Conflict of Interest: None.

Authors' Contribution

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

ME: & HK: Conception, interpretation of data, drafting the manu-script, approval of the final version to be published.

JM: & KS: Study design, data analysis, drafting the manuscript, cri-tical review, approval of the final version to be published.

KAB: & UF: Critical review, approval of the final version to be published.

AT; AA: Data acquisition, interpretation of data, approval of the final version to be published.

ZA: & AR: Study design, Drafting the manuscript, interpretation of data, approval of the final version to be published.

FH: Critical review, drafting the manuscript, approval of the final 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.

REFERENCES

1. Ramanan M, Chaseling R. Paediatric brain tumours treated at a single, tertiary paediatric neurosurgical referral centre from 1999 to 2010 in Australia. J Clin Neurosci 2012; 19(10): 1387-1391. doi: 10.1016/j.jocn.2012.01.028.
2. Schaller BJ, Modo M, Buchfelder M. Molecular imaging of brain tumors: a bridge between clinical and molecular medicine? Mol Imaging Biol 2007; 9(2): 60-71. doi: 10.1007/s11307-006-0069-9.
3. Aarsen FK, Van Dongen HR, Paquier PF, Van Mourik M, Catsman-Berrevoets CE. Long-term sequelae in children after cerebellar astrocytoma surgery. Neurology 2004; 62(8): 1311-1316. doi: 10.1212/01.wnl.0000120549.77188.36.
4. Soffietti R, Baumert BG, Bello L, Von Deimling A, Duffau H, Frénay M, et al. Guidelines on management of low-grade gliomas: report of an EFNS-EANO Task Force. Eur J Neurol 2010 ; 17(9): 1124-1133. doi: 10.1111/j.1468-1331.2010.03151.x.
5. Recinos PF, Sciubba DM, Jallo GI. Brainstem tumors: where are we today? Pediatr Neurosurg 2007; 43(3): 192-201. doi: 10.1159/000098831. PMID: 17409788.
6. Ney JP, Kessler DP. Neurophysiological monitoring during cervical spine surgeries: Longitudinal costs and outcomes. Clin Neurophysiol 2018; 129(11): 2245-2251. doi: 10.1016/j.clinph.2018.08.002.
7. American Society of Neurophysiological Monitoring. [Internet]. Available at: http://www.asnm.org (Accessed: June 21, 2022)
8. Jahangiri FR: Mapping of the Brain: Intraoperative Neurophysiological Monitoring (IONM). 2021.
9. Deletis V, Sala F. Intraoperative neurophysiological monitoring of the spinal cord during spinal cord and spine surgery: a review focus on the corticospinal tracts. Clin Neurophysiol 2008 ; 119(2): 248-264. doi: 10.1016/j.clinph.2007.09.135.
10. Kim K, Cho C, Bang MS, Shin HI, Phi JH, Kim SK. Intraoperative Neurophysiological Monitoring : A Review of Techniques Used for Brain Tumor Surgery in Children. J Korean Neurosurg Soc 2018; 61(3): 363-375. doi: 10.3340/jkns.2018.0078.
11. Slotty PJ, Abdulazim A, Kodama K, Javadi M, Hänggi D, Seifert V, Szelényi A. Intraoperative neurophysiological monitoring during resection of infratentorial lesions: the surgeon's view. J Neurosurg 2017 ; 126(1): 281-288. doi: 10.3171/2015.11.JNS15991.
12. Emara M, Mamdouh A, Elmaghrabi MM. Surgical outcome of posterior fossa tumours: a Benha experience. Egypt J Neurosurg. 2020; 35: 18.doi:10.1186/s41984-020-00083-w

13. Moussalem C, Ftouni L, Mrad ZA, Amine A, Hamideh D, Baassiri W, et al. Pediatric posterior fossa tumors outcomes: Experience in a tertiary care center in the Middle East. Clin Neurol Neurosurg 2020; 197(1): 106170. doi: 10.1016/j.clineuro. 2020.106170.
14. Kakar J, Ashraf J, Khan AA, Imran M, Rehmani MA, Ghori SA, et al. The Satisfactory Surgical Outcome of Posterior Fossa Brain Tumors in Children at Civil Hospital, Karachi. Asian J Neurosurg 2020; 15(2): 377-381. doi: 10.4103/ajns.AJNS_56_19.
15. Kim J, Graves CE, Jin C, Duh QY, Gosnell JE, Shen WT, et al. Intraoperative nerve monitoring is associated with a lower risk of recurrent laryngeal nerve injury: A national analysis of 17,610 patients. Am J Surg 2021; 221(2): 472-477. doi: 10.1016/j.amjsurg. 2020.10.013.
16. Ali L, Jahangiri FR, Ali A, Belkhair S, Elalamy O, Adeli G, et al. Emerging Super-specialty of Neurology: Intraoperative Neurophysiological Monitoring (IONM) and Experience in Various Neurosurgeries at a Tertiary Care Hospital in Doha, Qatar. Cureus 2021 ; 13(12): e20432. doi: 10.7759/cureus.20432.
17. Ishida W, Casaos J, Chandra A, D'Sa A, Ramhmdani S, Perdomo-Pantoja A, et al. Diagnostic and therapeutic values of intraoperative electrophysiological neuromonitoring during resection of intradural extramedullary spinal tumors: a single-center retrospective cohort and meta-analysis. J Neurosurg Spine 2019 : 1-11. doi: 10.3171/2018.11.SPINE181095.
18. ABRET: Neurodiagnostic credentialing and accreditation - CNIM exam eligibility requirements. (2021). [Internet]. Available at: https://www.abret.org/candidates/credentials/cnim/. (Accessed: June 22, 2022).
19. Gertsch JH, Moreira JJ, Lee GR, Hastings JD, Ritzl E, Eccher MA, et al; membership of the ASNM. Practice guidelines for the supervising professional: intraoperative neurophysiological monitoring. J Clin Monit Comput 2019; 33(2): 175-183. doi: 10.1007/s10877-018-0201-9.

....