The use of neural integrity monitor [NIM flex^{tm}] tube in patients undergoing posterior fossa surgery: our institutional experience

Vibhuti P Chauhan[1], Rajashree U Gandhe[2], Chinmaya P Bhave[3], Neha T Gedam[4]

From [1]Neuroanesthesia Fellow, [2]Senior Consultant and HOD, [3]Consultant, [4]Clinical Associate, Department of Neuroanesthesiology, Kokilaben Dhirubhai Ambani Hospital, Mumbai, India.

Correspondence to: Dr. Chinmaya P Bhave, Department of Neuroanesthesiology, Kokilaben Dhirubhai Ambani Hospital, Mumbai - 400053, Maharashtra, India. E-mail: bhavechinmaya@gmail.com

Received - 21 August 2019 Initial Review - 7 September 2019 Accepted - 16 October 2019

ABSTRACT

Neurosurgery for cerebellopontine angle tumour involves handling and dissection of cranial nerves at their origin from the brainstem. Lower cranial nerves or their nuclei may be affected by lesions arising from or extending up to the medulla. Preserving their structural and functional integrity is an important goal during surgical resection. Important functions of vagus nerve include swallowing, speech, respiration and heart rate control and its damage is one of the devastating complications of posterior fossa tumour resection. Electromyographic monitoring for recurrent branch of vagus nerve has been done in thyroid surgeries using a specially designed neural integrity monitor (NIM flex^{TM}) electromyogram (EMG) endotracheal tube containing embedded stimulating electrodes placed at the level of vocal cords. We present our experience with the use of this NIM flex^{TM} EMG endotracheal tube for vagus nerve monitoring in neurosurgery for posterior fossa tumours in four patients. Use of this tube in neurosurgery has been less reported in the Indian literature.

Keywords: *Electromyography, NIM flex^{TM} EMG endotracheal tube, Posterior fossa neurosurgery, Vagus nerve monitoring.*

Intraoperative identification of cranial nerves and nuclei along with their functional monitoring is very important in brainstem and skull base surgery. Surgical manipulation of these nerves may result in temporary or permanent loss of their function with the incidence reported to be around 5% following posterior fossa surgery [1].

There have been many reports suggesting use of intraoperative neuromonitoring to reduce the risk of postoperative neurological deficit after posterior fossa surgery [2-7]. Use of NIM FLEX ™ Electromyogram (EMG) tube [Medtronic, Jacksonville, Flo, USA] for intraoperative monitoring of recurrent branch of vagus nerve has been successfully recorded in thyroid surgery [8-11]. We present our experience in four patients with use of this tube in posterior fossa surgery which is less reported in Indian literature.

CASE SUMMARY

Here we are presenting a case series of 4 patients details of whom including age, sex, tumour diagnosis, chief complaints, local and general examination, pre and postoperative functioning of cranial nerves IX, X and post operative complications have been mentioned in Table 1. All 4 patients underwent posterior fossa craniotomy and tumour excision under general anesthesia.

Preoperative fasting, informed consent and routine laboratory investigations were checked. All American Society of Anaesthesiologists' (ASA) standard monitors were applied along with neuromuscular, temperature and bispectral index (BIS^{TM}) monitors. Patients were premedicated with intravenous midazolam 0.02mg/kg, fentanyl 1µg/kg and glycopyrrolate 10µg/kg in the operation theatre. Preoxygenation was done with 100% oxygen and anesthesia was induced with intravenous propofol 1-2mg/kg. Intravenous atracurium 0.5mg/kg was administered and trachea was intubated under direct laryngoscopy using

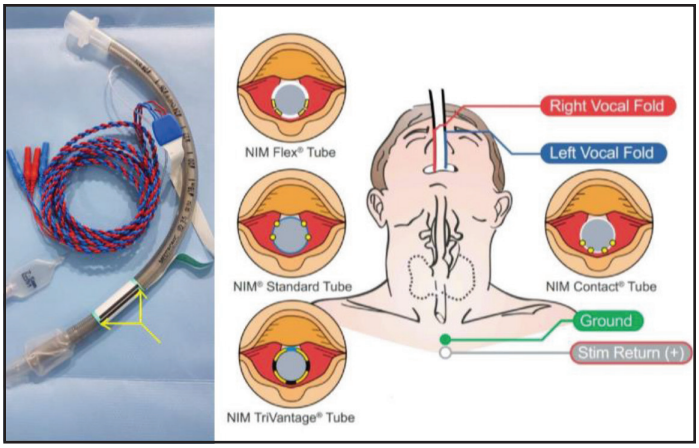

Figure 1: NIM flex^{TM} EMG tube with stimulating electrodes (yellow arrows) [Left] and types of Neural integrity monitor (NIM) electromyogram (EMG) tubes depending upon various surface electrodes in relation with vocal cords. [Right] Reproduced from Medtronic NIM^{TM} EMG tube brochure with permission.

appropriately sized unlubricated NIM flex™ EMG tube with the stimulating electrodes positioned at the level of the vocal cords.

The NIM flex™ EMG endotracheal tube is a flexible silicone elastomeric tube with an inflatable silicone cuff which causes minimal trauma to tissues by conforming readily to the shape of patient's trachea (Fig. 1). The tube was fitted with four stainless steel wire electrodes (two pairs) which were embedded in the silicone of the main shaft of the endotracheal tube. The electrodes are exposed to a very short distance, 30mm (3cm), superior to cuff for contact with the patient's vocal cords. This facilitates EMG monitoring of vocal cords during surgery when connected to multichannel monitoring device. Depending upon the position of 4 electrodes in relation to vocal cords, there are four variants of NIM flex™ EMG tube: NIM flex™ tube, NIM™ Trivantage tube, NIM™ contact tube and NIM™ standard tube (Fig. 1 {Reproduced from Medtronic™ brochure}). The NIM flex™ EMG endotracheal tube records the EMG activity of vocalis muscle by stimulating vagus nerve (in neurosurgery) or its recurrent branch (in thyroid surgery) by direct stimulation after its identification.

The endotracheal tube was fixed in the midline with bite block to prevent accidental damage to the tube and injury to the tongue. Needle electrodes were placed under vision for monitoring of other cranial nerves. All electrodes along with stimulation and ground electrodes were attached to stimulator box which was connected to nerve integrity monitor [NIM-Neuro 3.0 ™]. Continuous, low amplitude (30-70 μV) response was obtained from vocalis and all other muscles that were monitored which corresponded to resumption of spontaneous muscle activity.

Central venous catheter, invasive arterial blood pressure monitoring cannula and urinary catheter were inserted under aseptic precautions. The position of the endotracheal tube was reconfirmed after surgical positioning by direct laryngoscopy and intraoperative periodic checking of the impedance. Anaesthesia was maintained by mixture of air and oxygen (50:50) along with sevoflurane {0.5-1.0 minimum alveolar concentration [MAC]}; intravenous infusions of dexmedetomidine 0.2-0.7 μg/kg/h, propofol 0.02-0.05mg/kg/h and fentanyl 0.5-1 μg/kg/h. BIS™ values were kept in the range of 40-60. The train-of-four (TOF) ratio was kept 0.9-1.0, intraoperatively.

Table 1: Patient and surgery details

Patient Details	Tumour details	Presenting Complaints	Local and general examination	Pre operative nerve functioning (IX,X)	Postoperative nerve functioning (IX,X)	Remarks
64 year/ Male	Brainstem Choroid plexus papilloma grade III (Right side)	Imbalance while walking on right side, vertigo, nausea	Facial symmetry present, plantar bilaterally down going. Cerebellar signs positive (falls towards right side, right dysdiado-chokinesia, finger nose test +)	Normal	Reduced (swallowing difficulty) Required ryle's tube for 3 days. Gradually improved.	Nil
48 year/ male	Glioblastoma Multiforme (IV) with metastasis (Left side)	Imbalance while walking on left side, headache, giddiness, decreased swallowing more for solids.	Facial asymmetry present, planter bilaterally down going. Cerebellar signs positive (falls towards left side, left dysdiado-chokinesia, finger nose test +, tandem gait +). Weak cough and gag reflex	Reduced	Worsened. Required ryle's tube feeding for 10 days.	Aspiration pneumonia, hypoxia, poor prognosis
50 year/ female	Glomus tumour (Right side)	Tinnitus, hearing loss, involuntary facial movements	Right sided hearing loss, facial asymmetry present, reflexes normal, No cerebellar signs, Tandem gait positive right side	Normal	Normal	Nil
36 year/ Male	Acoustic neuroma (Right side)	Hearing loss, giddiness, Imbalance while walking on right side	Facial symmetry present, Reflex normal, cerebellar signs present (Falls towards right side, right dysdiadochokinesia) Tandem gait positive right side	Normal	Normal	Nil

Intraoperative mapping of the cranial nerves was done using handheld sterile monopolar stimulating probe with intensity 1.0-2.0mA for 0.2ms. The response was recorded as neurotonic burst – sinusoidal, high frequency (30-100Hz lasting for 300ms), continuous or intermittent waves on the NIM – Neuro 3.0 ™ monitor. The same was audible as "blurp". Intensity was reduced if response was exaggerated. Intravenous atropine 0.6mg bolus dose was kept ready to treat reflex bradycardia secondary to handling or stimulation of vagus nerve. Intraoperative haemodynamic parameters were stable in all patients. All patients were extubated after meeting the criteria and direct laryngoscopic visualization of vocal cord movements. Anatomical preservation of cranial nerves was achieved in all patients while functional impairment of vagus nerve was noticed in two patients postoperatively with one patient requiring reintubation after 10days.

DISCUSSION

Success of posterior fossa tumour surgery depends not only on extent of tumour resected but also on preservation of cranial nerves that may be compressed by the tumour. Technological advances in the field of neuromonitoring, imaging, neurosurgery and neuroanaesthesia have increased the safety and feasibility of brainstem surgery [12]. Somatosensory evoked potentials (SSEP), brainstem auditory evoked potentials (BAEP), corticobulbar motor evoked potentials (CoMEP) and corticospinal motor evoked potentials (MEP) are used for intraoperative monitoring of neural pathways.

EMG helps in mapping of cranial nerves, by observing responses in the muscles supplied by these nerves, thereby enabling neurosurgeon to preserve the nerve. The EMG technique cannot monitor the supranuclear pathway which is its main limitation. To test the complete integrity of the nerve from the motor cortex till its peripheral divisions, the EMG technique has to be combined with other neuromonitoring techniques like TcMEP, CoMEP. The goals of mapping techniques include identification of tumour not in contact with nerve, identification of nerve trajectory and predicting time for nerve injury.

Tumors in the brainstem or floor of fourth ventricle often grossly distort the normal anatomy and obscure anatomical landmarks on the floor of the fourth ventricle. Tumours located in the cerebromedullary cistern may involve lower cranial nerves, thus making the nerves difficult to see [2]. Surgical manipulations of vagus nerve and its nucleus will lead to paralysis, making swallowing and coughing difficult, resulting in aspiration.

EMG mapping of vagus nerve is done by observing response of vocalis muscles that are supplied by recurrent laryngeal branch of the nerve. Placement of needle electrodes in the vocalis muscles have been attempted either endoscopically, through cricothyroid membrane or by surgically exposing the muscles; all of which require meticulous skill, time and separate incisions [3, 7]. All these approaches are invasive and complicated. The electrodes can cause injury to the vocal cord mucosa and can also get dislodged intraoperatively. These techniques require frequent laryngoscopic visualization of electrode position and vocal cord movements when the nerve or its nucleus is stimulated. Due to these limitations, these techniques are not used commonly.

Mikuni N et al [2] used endotracheal tube surface electrode for mapping and monitoring the activity of vagus nerve in surgeries in the vicinity of medulla oblongata. They concluded that this tube could be used successfully to identify vagus motor nerve and evaluate its integrity. Ito et al [3] published a case report on use of NIM flex™ tube for monitoring of vagus nerve during craniotomy in two patients. They used NIM flex™ tube for identification of vagus nerve without any complications.

Topsakal et al [4] used a NIM flex™ EMG tube in 37 patients out of 123 for vagus nerve monitoring and suggested that the use of intraoperative neuromonitoring will reduce the injury to cranial nerves in high risk patients. Fukuda et al [5] used a novel device comprising of four contact electrodes attached to the surface of the cuff of an endotracheal tube with an additional attachment to the posterior pharyngeal wall. It was used for monitoring of glossopharyngeal and vagus nerves during skull base surgery. This device was used safely for monitoring of vagus and glossopharyngeal nerves.

Trentman et al [6] had reported one case with use of NIM flex™ EMG tube for monitoring of vagus nerve along with monitoring of other lower cranial nerves in a patient undergoing acoustic neuroma resection. Kartush et al [13] have mentioned placement of needle electrodes in laryngeal muscles for intraoperative monitoring of vagus nerve in neurosurgery.

CONCLUSION

Preservation of structural and functional integrity of cranial nerves is of prime importance and is one of the benchmarks of a successful posterior fossa tumour surgery. The NIM flex™ EMG endotracheal tube is relatively non traumatic; remains in contact with vocal cords with minimal chance of dislodgement and does not require specialist training for its use. Despite its high cost, it is a valuable vagus nerve mapping and monitoring tool in posterior fossa tumour surgery.

REFERENCES

1. Dubey A, Sung WS, Shaya M, Patwardhan R, Willis B, Smith D, *et al*. Complications of posterior cranial fossa surgery-an institutional experience of 500 cases. Surgic Neurol. 2009;72:369-75.
2. Mikuni N, Satow T, Taki J, Nishida N, Enatsu R, Hashimoto N. Endotracheal tube electrodes to map and monitor activities of the vagus nerve intraoperatively. J Neurosurg. 2004;101:536-40
3. Ito H, Sobue K, So M, Hirate H, Sugiura T, Azami T, *et al*. Intra-operative monitoring of vagal nerve activity with wire electrodes. Acta Anaesthesiol Scand. 2006;50:1304-5.
4. Topsakal C, Al-Mefty O, Bulsara KR, Williford VS. Intraoperative monitoring of lower cranial nerves in skull base surgery: technical report and review of 123 monitored cases. Neurosurg Rev. 2008;31:45-53.
5. Fukuda M, Takao T, Hiraishi T, Yagima N, Saito A, Fujii Y. Novel devices for intraoperative monitoring of Glossopharyngeal and vagus nerves during skull base surgery. Surg Neurol Int. 2013;4:97.

6. Trentman TL, Thunberg C, Gorlin A, Koht A, Zimmerman RS, Bendok B. Insertion of intra-oral electrodes for cranial nerve monitoring using a Crowe- Davis retractor. J Clin Monit Comput. 2017;31:793-6.
7. Ito E, Ichikawa M, Itakura T, Ando H, Matsumoto Y, Oda K *et al*. Motor evoked potential monitoring of the vagus nerve with transcranial electrical stimulation during skull base surgeries. J Neurosurg. 2013;118:195-201.
8. Hummerling TM, Schmidt J, Bosert C, Jacobi KE, Klein P. Intraoperative monitoring of recurrent laryngeal nerve in 151 consecutive patients undergoing thyroid surgery. Anesth Analg. 2001;93:396-9.
9. Julien N, Mosnier I, Bozorg A, Nys P, Ferrary E, Sterkers O. Intraoperative laryngeal nerve monitoring during thyroidectomy and parathyroidectomy: A prospective surgery. Eur Ann Otorhinol, Head Neck Dis. 2013;129:69-76.
10. Dixit H, Kamat L, Potdar M, Modi T. Role of electromyography endotracheal tube in preventing recurrent laryngeal nerve injury during thyroid surgery: A case report. Indian J Anaesth. 2017;61:435-7.
11. Tsai CJ, Tseng KY, Wang FY, Lu IC, Wang HM, Wu CW *et al*. Electromyographic endotracheal tube placement during thyroid surgery in neuromonitoring of recurrent laryngeal nerve. The Kaohsiung Journal of Medical Sciences. KJMS. 2011;27:96-101.
12. Deletis V, Fernández-Conejero I. Intraoperative monitoring and mapping of the functional integrity of the brainstem. J Clin Neurol. 2016;12:262-73
13. Kartush JM, Larouere MJ, Graham MD, Bouchard KR, Audet BV. Intraoperative cranial nerve monitoring during posterior skull base surgery. Skull Base Surg. 1991;1:85-92.

Funding: None; Conflict of Interest: None Stated.

How to cite this article: Chauhan VP, Gandhe RU, Bhave CP, Gedam NT. The use of neural integrity monitor [NIM flex^{tm}] tube in patients undergoing posterior fossa surgery: our institutional experience. Indian J Case Reports. 2019;5(5):495-500.

Doi: 10.32677/IJCR.2019.v05.i05.032