CANADIAN IONM NEWS
Official Newsletter of CANM

Message from the PRESIDENT

Dear Colleagues,

It was great to see those who attended the 11th annual CANM Symposium in Calgary last month. To the symposium organizing committee I extend an enthusiastic thank you for delivering another excellent two day program. For those who were unable to attend we hope to see you next year.

Since its inception the CANM symposium has been a consistent benefit to my professional development. I could easily compose a list of the influential pearls I have learned by attending this meeting. I hope that others have had a similar experience. Of the many outstanding contributions to this year's symposium what struck me in particular was an articulate analysis of EEG and depth of anesthesia by Dr. Emery Brown of MIT. He eloquently demonstrated that using readily available OR monitoring equipment insights into questions of relevance to both neuromonitorists and anesthesiologists can be achieved. My other favourite was the "axonal memory" demonstration provided by Dr. Kelvin Jones and Dr. Aleksandra King from the University of Alberta. This was particularly relevant to recently published observations related to facial MEP but was also an entertaining exercise that generated plenty of discussion. Stay tuned to this channel for information on next year's symposium!

I am also super enthusiastic about the new group of people starting their careers in neuromonitoring in Canada and particularly those who have completed the Michener program. What an enormous advantage these people have going forward. Ours is a complex and highly integrative field. The Michener course positions grads to achieve the integration of their education with real OR events at a much faster rate than would otherwise be possible. I am looking forward to the contributions that these next generation neuromonitorists make to our profession, our Association and to neurophysiological research as well.

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As leaders in our field it remains in our hands to provide quality neuromonitoring for our patients but also to contribute leadership in the research arena. These two issues are not inseparable. While not everyone in neuromonitoring may have the time, autonomy, or desire to conduct independent studies certainly all of us should be able to critically examine the neuromonitoring literature. In this issue an examination of some research activity will be presented by our contributors. The goal is twofold: 1) to make readers aware of some of the research activity in our professional community, and 2) to reinforce, through critical review, that just because something gets published does not necessarily mean that the work is infallible.

Until next time,

Marshall Wilkinson BSc (Hon), MSc, PhD
President, CANM & Neurophysiologist
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11th Annual IONM Symposium

The Annual CANM Symposium has earned a reputation throughout North America as one of the foremost educational events for IONM practitioners. The 11th Annual CANM Symposium held in the beautiful up-and-coming area of East Village in downtown Calgary, AB, surpassed expectations! This year's symposium showcased a distinguished group of surgeons, anaesthetists, and IONM professionals speaking on a variety of cutting-edge topics in the field of neuromonitoring.

Leading the way was our keynote speaker, Charles Dong, PhD from Vancouver General Hospital. Dr. Dong is a founding member of CANM and has served as Board Member and Chair of the Education Committee of the International Society of Intraoperative Neurophysiology. His keynote presentation focussed on his pioneering work in the area of corticobulbar MEP monitoring. He followed this with a second talk on intraoperative monitoring of auditory evoked potentials. Rounding out the discussion on the brainstem was an impressive presentation on mapping of brainstem nuclei by Iaonnis Karakis MD, PhD from Emory University's School of Medicine.

Keynote Speaker Dr. Charles Dong

11th Annual IONM Symposium

Local Calgary surgeons from particularly strong programs in Spine and Neuro also shared their expertise with our attendees. Dr. Rajiv Midha, an internationally-recognized authority on peripheral nerve injury, spoke on advances in peripheral nerve repair. Dr. Zelma Kiss presented on the anatomical targets of deep brain stimulation as well as the signature neural responses at each location. Dr. Ganesh Swamy discussed the benefits of direct lateral interbody fusions over other types of fusion procedures. All shared their views on the importance of neuromonitoring for prevention of neural injury and localization of critical neural structures.

Definitely a highlight of the symposium was the impressive lecture by Emory Brown, MD, PhD. Dr. Brown is an anesthesiologist-statistician, dual-appointed to Harvard and MIT, whose experimental research has made fundamental contributions to understanding the neuroscience of how anesthetics create the states of general anesthesia. His presentation on the use of EEG for depth of anesthesia evoked literal "oohs" and "ahs" from the audience and introduced a more nuanced method for interpreting EEGs to aid anesthetists.

The intimate environment of the CANM Symposium has traditionally promoted valuable interaction among attendees. In keeping with this tradition, this year we included a live demonstration of axon excitability and their "memory traces", organized by Kelvin Jones, PhD. This session garnered significant accolades from our colleagues, not only for its fascinating topic, but also for easing the audience into constructive and inclusive dialogue.

Events such as these cannot be successful without an engaged group of attendees. This year's symposium was very well-attended, with many of our attendees hailing from the US, which allowed for diverse experiences and perspectives to contribute to our lively discussions. I would like to thank all of our colleagues in attendance, volunteer speakers, and the organizing committee for making the 11th Annual CANM Symposium such a success!

Jamie Johnston, PhD, CNIM
11th Annual CANM Symposium Organizing Committee Chair
CANM President-Elect

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NEUROPHYSIOLOGIC MONITORING AND MAPPING OF THE CRANIAL NERVES AND THE BRAINSTEM

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Director of Intraoperative Monitoring
Emory University School of Medicine

INTRODUCTION

The brainstem constitutes a delicate surgical site due to its complex neuroanatomy and critical role in vital functions. Intraoperative neurophysiology can facilitate a surgical intervention to the brainstem by identifying anatomically ambiguous nervous tissue to obtain a safe entry zone and by providing an online assessment of the functional integrity of the neural pathways at stake (monitoring) (Sala *et al.*, 2002).

Traditional neurophysiologic techniques, such as brainstem auditory evoked potential and somatosensory evoked potentials can only evaluate 20% of the brainstem (Fahlbusch and Strauss, 1991). Therefore, intraoperative neurophysiology has adapted newer techniques to better localize and monitor the cranial nuclei and the cranial nerves (CN), in addition to the descending corticobulbar (CBT) and corticospinal (CST) tracts (Sala *et al.*, 2007).

ANATOMY and PATHOPHYSIOLOGY

Intrinsic lesions of the midbrain can be divided into those situated primarily in the tectum, dorsally, and those located mostly in the tegmentum, ventrally. Dorsal approaches endanger the decussation of the fourth cranial nerve and the collicular connections to the thalamus. Ventral approaches endanger the third nerve and the cerebral peduncles.

Lesions located in the pons can be accessed either through the floor of the fourth ventricle dorsally or via the basis pontis ventrally. Lesions within the floor of the fourth ventricle generally are considered resectable if they present to the surface. The critical structures to avoid are represented on the surface of the floor of the fourth ventricle by the facial and hypoglossal colliculi. The facial colliculi, formed by the sixth nerve nuclei and the overlying traversing fibers of the seventh nerve, are located in the base of the rostral triangle of the rhomboid fossa. These structures are within 2-4 mm from the surface. Striae medullares are transversely coursing fibers that run across the floor of the fourth ventricle indicating the transition from pons to medulla oblongata (Carpenter, 1991). In the medulla, the less prominent hypoglossal colliculi represent the rostral portion of the hypoglossal nuclei. There is significant anatomic heterogeneity of the aforementioned landmarks. In addition, there are many important structures not immediately evident externally. Specifically, in close association with the hypoglossal nucleus is the dorsal parasympathetic motor nucleus of the vagus nerve. Lateral to this the solitary nucleus is found and most laterally the vestibular nuclei are located. Just ventral to them are the motor and principle sensory trigeminal nuclei.

There is no wide consensus regarding the safest ways to violate the surface of the medulla. Externally salient features of the medulla include the midline sulcus between the protuberances of the fasciculi gracili, the shallower protuberances of the cuneate fascicles more laterally, the bulges of the inferior olivary nuclei laterally, and the corticospinal tracts with their pyramidal decussation ventrally. The glossopharyngeal nerve (CN IX) exits from the more rostral portion of the medulla's posterolateral sulcus. The vagus (CN X) and accessory (CN XI) nerves exit from this same sulcus more caudally. The hypoglossal (CN XII) nerve exits from the anterolateral sulcus.

Most brainstem tumors displace the cranial motor nuclei (CMN) in a stereotypical manner (Morotta *et al.*, 1996). Specifically, the transverse pontine fibers allow tumors to grow circumferentially. On the other hand, medullary tumors grow more exophytically. The pontomedullary and cervicomedullary junctions act as physiologic barriers that affect tumor growth (Epstein and Farmer, 1993). Pontine tumors do not typically displace lower CMN that are nearly always near the obex and medullary tumors typically do not shift the location of the facial colliculus (Morota *et al.*, 1996). Cervicomedullary spinal cord tumors do not compress the lower CMN but just displace them around the edge of the tumor. A notable exception appears to be pontomedullary lesions of the dorsal rhombencephalon that grow exophytically on the floor of the 4th ventricle (Morota *et al.*, 1996).

TECHNIQUES

In addition to traditional techniques for monitoring BAERs, SSEPs and corticospinal MEPs, that will not be described herein, more advanced techniques have been implemented over the past two decades to map and monitor the cranial nuclei and cranial nerves, in addition to the corticobulbar tracts (CBT).

I) CMN and CN MAPPING and MONITORING

Numerous stimulating and recording paradigms have been reported, and there is no single optimal methodology (Lopez, 2008).

Electrical stimulation of the CMN and the exiting cranial nerves can occur both with a bipolar or, preferably, with a monopolar handheld stimulator (Strauss *et al.*, 1993). When a bipolar stimulator is used, the tips should be adequately distanced by 6-10 mm, and if the floor of the 4th ventricle is stimulated, the stimulator should be placed transversely, given that the facial nerve fibers course laterally on the facial colliculus (Katsuta *et al.*, 1993). The medial electrode should be connected to the anode and the lateral to the cathode to avoid anodal block through propagation toward the facial muscle (Katsuta *et al.*, 1993). A test stimulation directly on an adjacent to the surgical site muscle to provoke a visible contraction helps confirm its functionality. Stimulation distances of 1 mm and duration of <5 sec at a time are advised. Square wave pulses at 0.2 msec, 2-4 Hz and no more than 2 mA are commonly applied (Karakis, 2013). Exceeding these parameters has been occasionally linked to cardiovascular instability (Suzuki *et al.*, 1997). Once maximal response is acquired, the current is reduced to identify a threshold for more selective localization of the mapping target. That threshold can vary depending on the underlying pathology and distance of the CMN or CN from the stimulation site (Lopez, 2008). It can be as low as 0.2 mA in hematomas, but tumors typically have higher requirements (Morota and Deletis, 2006).

Responses are recorded from the muscles innervated by the stimulated CMN and CN. Special attention and, not uncommonly, multidisciplinary assistance is warranted for needle positioning in extraocular muscles, in the stylopharyngeus muscle and in the vocal cords. If that is not available, mapping and monitoring of the CMN/nerves for the extraocular muscles can be done with electro-oculographic responses through surface electrodes (Fukaya *et al.*, 1999), though sensitivity and specificity is somewhat compromised. Similarly, mapping and monitoring the IX and X CMN/CN can be done with less invasive methods such as electrodes mounted on the cuff of a laryngeal mask airway or endotracheal tube (Husain *et al.*, 2008). Typical recording parameters are 3-5 ms/division sweep, 50 uV/division gain, 10,000 times amplification with a high pass filter as 3,000 Hz and a low pass filter at 20 Hz (Karakis, 2013). In addition to inspection, immediate auditory feedback can be provided to the neurosurgeon, if the generated EMG responses are projected to a loudspeaker.

Accurate localization of the CMN and exiting CN is essential. This can be achieved by keeping the stimulus intensity low and the stimulator steady, while searching for generated responses in the recorded muscles (Sala *et al.*, 2007). Clearing the surgical field from fluid and blood before the stimulation prevents current spread and facilitates specificity (Eisner *et al.*, 1995). The selectivity of the responses excludes widespread brainstem stimulation (Strauss *et al.*, 1999) or volume conduction at an adjacent recorded muscle (Morota *et al.*, 1995). When mapping the floor of the fourth ventricle, the facial colliculus commonly responds to a larger area of stimulation, due to its large size (Lang *et al.*, 1991). Conversely, CMN IX/X are localized in confined submillimeter areas (Morota *et al.*, 1995). Simultaneous, bilateral recordings allow for side selectivity testing. Each patient can act as his/her own control. In unilateral lesions, stimulation of the contralateral side can provide useful information on the required stimulus threshold and anticipated response characteristics (Lopez, 2008). The definition of a critical change is not clear cut, but patients with unchanged triggered EMG responses post resection are typically spared from postoperative deficits. Yet, if stimulus intensity requirements increase throughout the case, or if generated responses decrease in amplitude from baseline, a new or worsening, transient or permanent postoperative deficit is possible (Lopez, 2008). An absent response in the recording muscle is not equivalent to a non functional CMN or CN. It can be merely the effect of a malfunctioning stimulator, dislodged or misplaced recording electrodes, inappropriate stimulation location or intensity, ventrally displaced CMN from underlying pathology or neuromuscular blockade. Conversely, the presence of a triggered response cannot fully exclude an optimal clinical outcome. False negative responses can occur when the stimulation takes place distal to the site of injury or the supranuclear input from the descending CBT is interrupted (Morota *et al.*, 1995). That is particularly true for medullary surgeries where postoperative dysarthria and dysphagia can be observed, despite preserved stimulation responses, due to impairment of the afferent pathways to the CMN that NIOM cannot reliably detect (Morota and Deletis, 2006). Changes in latency are infrequent besides temperature effects (Lopez, 2008). When auditory feedback is in place, cross-reference with visual input should be performed to elucidate the origin and significance of acquired EMG responses (Eisner *et al.*, 1995).

For monitoring of the CMN and the motor nerves, spontaneous EMG activity in innervated muscles has been found to be a reliable marker of mechanical, thermal, or metabolic irritation of the relevant nuclei or nerves. Three different patterns of free run EMG activity have been described (Romstock *et al.*, 2000). Type A are trains of EMG activity, of 100-200 uV up to 400 uV amplitude and a frequency of 60-210 Hz, lasting between a few milliseconds to seconds. They are usually observed with compression, traction and ischemia of the nerve and are associated with a poor prognosis. B trains consist of runs of spikes or bursts at relatively regular intervals; the amplitude varies from 20 uV to 5000 uV. C trains consist of irregular, high frequency muscle activity, with a wide range of amplitudes, from 20 to 5000 uV. Unlike A trains, B and C trains are "benign" and do not correlate with poor outcome; they usually occur at nerve contact, irrigation of the surgical field and are consistently seen during pain triggering surgical steps.

Triggered EMG can be obtained by electrical stimulation of the cranial nerve either with bipolar or with monopolar stimulation handheld probe. The stimulation intensity threshold varies according to the other parameters (pulse duration) as well as to the state of the nerve (an injured nerve will depolarize at higher threshold). For a healthy nerve, thresholds as low as 0.1 mA for a 0.2 msec pulse duration and up to 1 mA for 0.1 msec pulse duration.

II) CBT MONITORING

During brainstem surgery, postoperative cranial nerve dysfunction can arise not only from direct injury of the cranial nerves and nuclei but also from injury to the corticobulbar tracts innervating these nuclei. The advantages of MEPs recording over that of triggered CMAPs are evident. First, they offer an assessment of the entire motor pathway at risk, not only distal to the cranial nerves nuclei but also proximal to it. Second, MEPs recording technique allows direct monitoring rather than intermittent mapping of the function of the motor cranial nerves.

For transcranial stimulation, a train of 5 stimulations with 250-500 Hz and interstimulus interval up to 200 mAmp is typically used. Due to the short latency of observed responses and, hence, increased risk for stimulus artifact, placing the stimulating electrodes as close as possible to the face region on the motor homunculus may help (C3/C4/Cz location as well as 2 cm anterior and inferior of C3/C4).

Recording is typically performed from the muscles innervated by the CMN/CN receiving supranuclear input through these tracts, but it can also be performed directly from the pyramidal tracts through an epidural electrode inserted at C1-C2 through a suboccipital craniotomy (D-wave) (Sala *et al.*, 2007).

In order to reliably map the descending CBT and CST, one has to avoid co-stimulation of the CMN and exiting CN. That can be challenging if high currents are used. If a muscle response is obtained after a train of stimulation and not after a single one, while keeping the other stimulation parameters steady, then it is likely generated from CBT stimulation (Morota *et al.*, 2010, Sala *et al.*, 2007). Recording appendicular responses with direct brainstem stimulation can also provide information about the localization of the CST (Neuloh *et al.*, 2009). If repeated responses are obtained throughout the surgery, a 50% reduction of amplitude is generally considered to be significant, similar to supratentorial cases (Dong *et al.*, 2005, Neuloh *et al*,. 2009, and Sala *et al.*, 2007). Finally, it should be noted that responses generated through transcranial CBT stimulation tend to be smaller compared to direct CMN/CN generated responses and, therefore, relying solely on CBT amplitude changes for prognostication may not be entirely reliable (Dong *et al.*, 2005).

III) BRAINSTEM REFLEXES

Traditional brainstem mapping and monitoring techniques may not be sufficient to avert neurological deficits when complex integrative pathways (e.g. speech, swallowing, conjugate gaze) are at stake. In attempt to address this limitation, techniques to intraoperatively study brainstem reflexes have been described.

Deletis and colleagues described a technique to obtain blink reflexes under general anesthesia (Deletis *et al.*, 2009). Stimulation was performed in the supraorbital nerve of either side of the face using a pair of subcutaneously inserted EEG needle electrodes or surface electrodes over the supraorbital nerve. These investigators used 1-7 rectangular constant-current stimulus with interstimulus interval of 2 ms, intensity 20-40 mA and a train repetition rate of 0.4 Hz. Recording was performed with needle electrodes inserted in the orbicularis oculi muscle ipsilateral to the stimulation side by averaging two single sweeps, reversing the stimulating electrode polarity after the first sweep to avoid stimulus artifact. 50 ms epoch and bandpass digital filters of 70-1219 Hz were used. Four stimuli were the optimal number needed to overcome anesthetic effects on eliciting an R1 response with a latency of 8.9-16.5 ms. An R2 response was still unobtainable, likely accounting for the polysynaptic pathway of that component of the blink reflex. Blink reflexes can be used to

evaluate for hyperexcitability of the facial motor nucleus in patients with hemifacial spasm. Smaller responses or higher numbers of stimuli needed to reproduce a blink reflex during a microvascular decompression for hemifacial spasm has been interpreted as a sign of successful separation of the nerve fibers from the aberrant artery irritating them (Fernandez-Conejero *et al.*, 2012). The same concept applies with reduction of F waves persistence or disappearance of lateral spreading responses (LSR) when the offending vessel is moved off the facial nerve (Fernandez-Conejero *et al.*, 2012). The latter are obtained through alternating stimulation of the marginal mandibular and zygomatic branches of the facial nerve through subdermal needle electrodes. A single constant current stimulus of 0.2 ms duration and 1 Hz stimulation rate up to 50 mA is recommended, recording through needle electrodes in the orbicularis oculi and mentalis (Fernandez-Conejero *et al.*, 2012).

A masseter reflex can be obtained with stimulation of the masseter nerve with a pair of hook-wire electrodes or a pair of monopolar EMG electrodes inserted under the zygomatic arch approximately 0.5 cm lateral to the temporomandibular joint, while recording with subdermal needle electrodes placed in the ipsilateral temporalis and masseter muscles. Single stimuli of 0.2-0.5 ms and steady increase in stimulus intensity is applied, using a repetition rate of 0.7-1 Hz with a 20 ms epoch and bandpass filters 1-2,133 Hz (Deletis *et al.*, 2016). A similar set up has been applied to masseter M and H reflexes (Ulkatan *et al.*, 2017). The mean onset latencies of the masseter H reflex and the M response were 5.4 ± 1.3 ms and 2.6 ± 0.6 ms, respectively. It remains to be seen if such a test could predict successful decompression in microvascular decompression for trigeminal neuralgia.

Recently, the laryngeal adductor reflex has been described (Sinclair *et al.*, 2017). The afferent pathway of this reflex consists of the ipsilateral superior laryngeal nerve, while the efferent pathway consists of the contralateral inferior laryngeal nerve after reaching the nuclear tractus solitarius and then nucleus ambiguous in the medulla. Testing is performed through electrical stimulation of one side of the endotracheal tube and recording on the opposite side via a pair of embedded electrodes. Single stimulus (0.1-1 ms duration) or paired stimuli (ISI 2-4 msec) at intensity up to 4 mA are applied. Two responses elicited by reverse polarity are averaged to reduce stimulus artifact. Signals are amplified (1000-4000) and filtered (1.5-1000 Hz).

The vestibular-evoked myogenic potential (VEMP) is an otolith-mediated, short latency reflex recorded as an electromyographic response to the sternocleidomastoid in response to intense auditory clicks (Welgampola *et al.*, 2005). VEMPs have been performed intraoperatively through direct stimulation of the exposed inferior vestibular nerve while recording EMG with subdermal needles electrodes from the ipsilateral SCM referenced to the upper sternum. Bipolar electric stimuli were applied with an intensity of 0.4-1mA, with a duration of 0.2 ms and a frequency of 4.7 Hz. The mean latencies were 9.1 (+/- 2.2 ms) for P13 and 13.2 (+/- 2.3 ms) for N23. The intraoperative VEMP responses correlated well in shape but not in latencies with extraoperative responses to acoustic stimulation for the same patients. By using this approach, monitoring of the inferior vestibular nerve during acoustic neuroma resections or VIII nerve microvascular decompressions can be performed (Ernst *et al.*, 2006).

ANESTHETIC CONSIDERATIONS

Transcranial MEPs are affected by inhalational agents and muscle relaxants. If D waves are recorded, that limitation does not apply. Free and triggered EMG activity used in CMN and CN monitoring is affected by muscle relaxants use. Polysynaptic responses of brainstem reflexes tend also to be susceptible to anesthetic agents.

SAFETY CONSIDERATIONS

Available data on brainstem mapping have not identified permanent deficits (Morota *et al.*, 1995, Strauss *et al.*, 1993). Transient cardiac arrhythmias and mild transient hypertension have been exceptionally reported with stimulation of the lower cranial motor nuclei in the vagal trigone (Morota *et al.*, 1995, Strauss *et al.*, 1999). With stimulus intensity up to 2 mA, duration up to 400 ms and frequency up to 10 Hz, no cardiovascular complications were noted (Strauss *et al.*, 1999).

APPLICATIONS

Brainstem mapping and monitoring was introduced in neurosurgery in the early 1990s (Katsuta 1993, Morota 1995). Nowadays, it is considered an indispensable tool for any type of surgery that jeopardizes the brainstem itself or the exiting cranial nerves.

LIMITATIONS

Application and interpretation of the aforementioned techniques requires detailed anatomic knowledge and neurophysiologic expertise. Certain structures are hard to reliably stimulate, particularly when underlying pathology distorts normal anatomy or preexisting deficits exist. Recording from certain targets such as extraocular muscles, the vocal cords/cricothyroid muscle and the posterior pharyngeal wall requires a multidisciplinary team. Preserved responses do not always exclude postoperative deficits, particularly when supranuclear input or complex integrative networks sub serving speech and swallowing are at stake. Finally, it should be emphasized that brainstem mapping is not equivalent to monitoring, and the two should be used in conjunction (Karakis, 2013)

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FUTUTE DIRECTIONS

The aforementioned techniques need standardization. Mapping and monitoring of integrative polysynaptic pathways serving speech, swallowing, gaze and coordination remains to be explored (Sala *et al.*, 2002).

CONCLUSIONS

Because the brainstem and cranial nerves contain a rich mixture of motor and sensory functions, working in this region requires a versatile array of neurophysiological monitoring strategies and a multidisciplinary approach towards a common goal of safeguarding brainstem integrity.

ACKNOWLEDGEMENT

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REFERENCES

1. Sala F, Krzan MJ, Deletis V. Intraoperative neurophysiological monitoring in pediatric neurosurgery: why, when, how? Childs Nerv Syst 2002;18:264–287.
2. Fahlbusch R, Strauss C. Surgical significance of cavernous hemangioma of the brain stem. Zentralbl Neurochir. 1991;52(1):25-32.
3. Sala F, Manganotti P, Tramontano V, et al.. Monitoring of motor pathways during brainstem surgery: what we have achieved and what we still miss? Neurophysiol Clin 2007;37:399–406.
4. Carpenter M, ed. Core Text of Neuroanatomy, 4th edition, chapter 2. Baltimore, Williams & Wilkins, 1991, pp 42–48.
5. Morota N, Deletis V, Lee M, Epstein FJ. Functional anatomic relationship between brain-stem tumors and cranial motor nuclei. Neurosurgery 1996;39:787–793; discussion 793–794.

REFERENCES

6. Epstein FJ, Farmer JP. Brain-stem glioma growth patterns. J Neurosurg. 1993 Mar;78(3):408-12.
7. Lopez JR. Mapping the brainstem: floor of the fourth ventricle. In: Nuwer MC (ed): Intraoperative Monitoring of Neural Function: Handbook of Clinical Neurophysiology. Elsevier,2008, pp 350–362.
8. Strauss C, Romstock J, Nimsky C, Fahlbusch R. Intraoperative identification of motor areas of the rhomboid fossa using direct stimulation. J Neurosurg 1993;79:393–399.
9. Katsuta T, Morioka T, Fujii K, Fukui M. Physiological localization of the facial colliculus during direct surgery on an intrinsic brainstem lesion. Neurosurgery 1993;32:861–863; comment 863.
10. Karakis, I. Brainstem mapping. J Clin Neurophysiol. 2013 Dec;30(6):597-603.
11. Suzuki K, Matsumoto M, Ohta M, et al.. Experimental study for identification of the facial colliculus using electromyography and antidromic evoked potentials. Neurosurgery 1997;41:1130–1135; discussion 1135–1136.
12. Morota N, Deletis V. The importance of brainstem mapping in brainstem surgical anatomy before the fourth ventricle and implication for intraoperative neurophysiological mapping. Acta Neurochir (Wien) 2006; 148:499-509; discussion 509.
13. Fukaya C, Katayama Y, Kasai M, Kurihara J, Yamamoto T. Intraoperative electrooculographic monitoring of oculomotor nerve function during skull base surgery. Technical note. J Neurosurg. 1999 Jul;91(1):157-9.
14. Husain AM, Wright DR, Stolp BW, Friedman AH, Keifer JC. Neurophysiological intraoperative monitoring of the glossopharyngeal nerve: technical case report. Neurosurgery. 2008 Oct;63(4 Suppl 2):277-8; discussion 278.
15. Eisner W, Schmid UD, Reulen HJ, et al.. The mapping and continuous monitoring of the intrinsic motor nuclei during brainstem surgery. Neurosurgery 1995;37:255–265.
16. Strauss C, Romstock J, Fahlbusch R. Pericollicular approaches to the rhomboid fossa. Part II. Neurophysiological basis. J Neurosurg 1999;91:768–775.
17. Morota N, Deletis V, Epstein FJ, Kofler M, Abbott R, Lee M, Ruskin K. Brain stem mapping: neurophysiological localization of motor nuclei on the floor of the fourth ventricle. Neurosurg 1995; 37:922-930.
18. Lang J Jr, Ohmachi N, Lang J, Sr. Anatomical landmarks of the Rhomboid fossa (floor of the 4th ventricle), its length and its width. Acta Neurochir (Wien) 1991;113:84–90.
19. Romstock J, Strauss C, Fahlbusch R. Continuous electromyography monitoring of motor cranial nerves during cerebellopontine angle surgery. J Neurosurg 2000; 93:586-593.
20. Morota N, Ihara S, Deletis V. Intraoperative neurophysiology for surgery in and around the brainstem: role of brainstem mapping and corticobulbar tract motor-evoked potential monitoring. Childs Nerv Syst 2010;26:513–521.
21. Neuloh G, Bogucki J, Schramm J. Intraoperative preservation of corticospinal function in the brainstem. J Neurol Neurosurg Psychiatry 2009;80:417–422.
22. Dong CC, Macdonald DB, Akagami R, et al.. Intraoperative facial motor evoked potential monitoring with transcranial electrical stimulation during skull base surgery. Clin Neurophysiol 2005;116:588–596.
23. Deletis V, Urriza J, Ulkatan S, Fernandez-Conejero I, Lesser J, Misita D. The feasibility of recording blink reflexes under general anesthesia. Muscle Nerve. 2009 May;39(5):642-6.
24. Fernández-Conejero I, Ulkatan S, Sen C, Deletis V. Intra-operative neurophysiology during microvascular decompression for hemifacial spasm. Clin Neurophysiol. 2012 Jan;123(1):78-83.
25. Deletis V, Fernández-Conejero I. Intraoperative Monitoring and Mapping of the Functional Integrity of the Brainstem. J Clin Neurol. 2016 Jul;12(3):262-73.
26. Ulkatan S, Jaramillo AM, Téllez MJ, et al. Feasibility of eliciting the H reflex in the masseter muscle in patients under general anesthesia. Clin Neurophysiol. 2017 Jan;128(1):123-127.
27. Sinclair CF, Téllez MJ, Tapia OR, Ulkatan S, Deletis V. A novel methodology for assessing laryngeal and vagus nerve integrity in patients under general anesthesia. Clin Neurophysiol. 2017 Jul;128(7):1399-1405.
28. Welgampola MS, Colebatch JG. Characteristics and clinical applications of vestibular-evoked myogenic potentials. Neurology. 2005 May 24;64(10):1682-8.
29. Ernst A, Todt I, Seidl RO, Eisenschenk A, Blödow A, Basta D. The application of vestibular-evoked myogenic potentials in otoneurosurgery. Otolaryngol Head Neck Surg. 2006 Aug;135(2):286-90.

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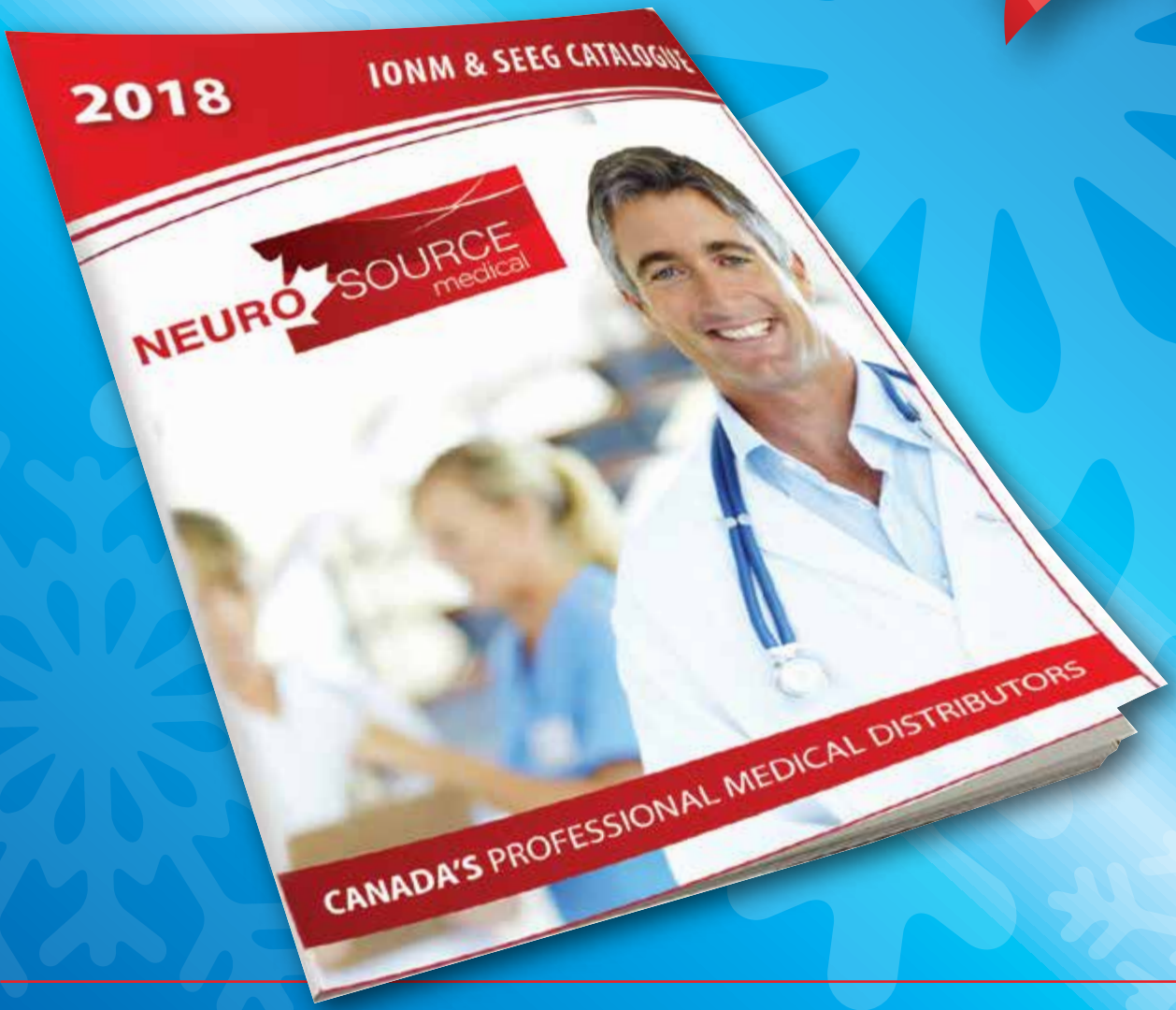

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This section is devoted to celebrating the accomplishments of members of our Canadian IONM community and recognizing them for their contributions and achievements no matter how big or small. Please join us in congratulating the following CANM Superstars.

CANM Superstar

Nancy Lu

Toronto Western Hospital, Toronto, ON

CANM owes a huge debt of gratitude to Nancy for the tireless number of hours she's spent over the years supporting CANM in a variety of roles, including most recently as Treasurer. Nancy's dedication to advancing our profession deserves to be celebrated and we are happy to count her among our most active members.

Francois Roy

University of Alberta, Edmonton, AB

Francois and his wife recently welcomed a new baby to the family.

Samuel Strantzas

SickKids, Toronto, ON

Sam, along with members of the Neurology department at SickKids, recently published an article on intraoperative cortical motor mapping.

Thanks for Being

Are YOU a CANM Superstar?

Do you KNOW a CANM Superstar?

CANM Superstars are members of the Canadian IONM community who we would like to recognize for their contributions, but we need your help! Please send us the accomplishments that should be celebrated in the next issue of Canadian IONM News by submission to **info@canm.ca**

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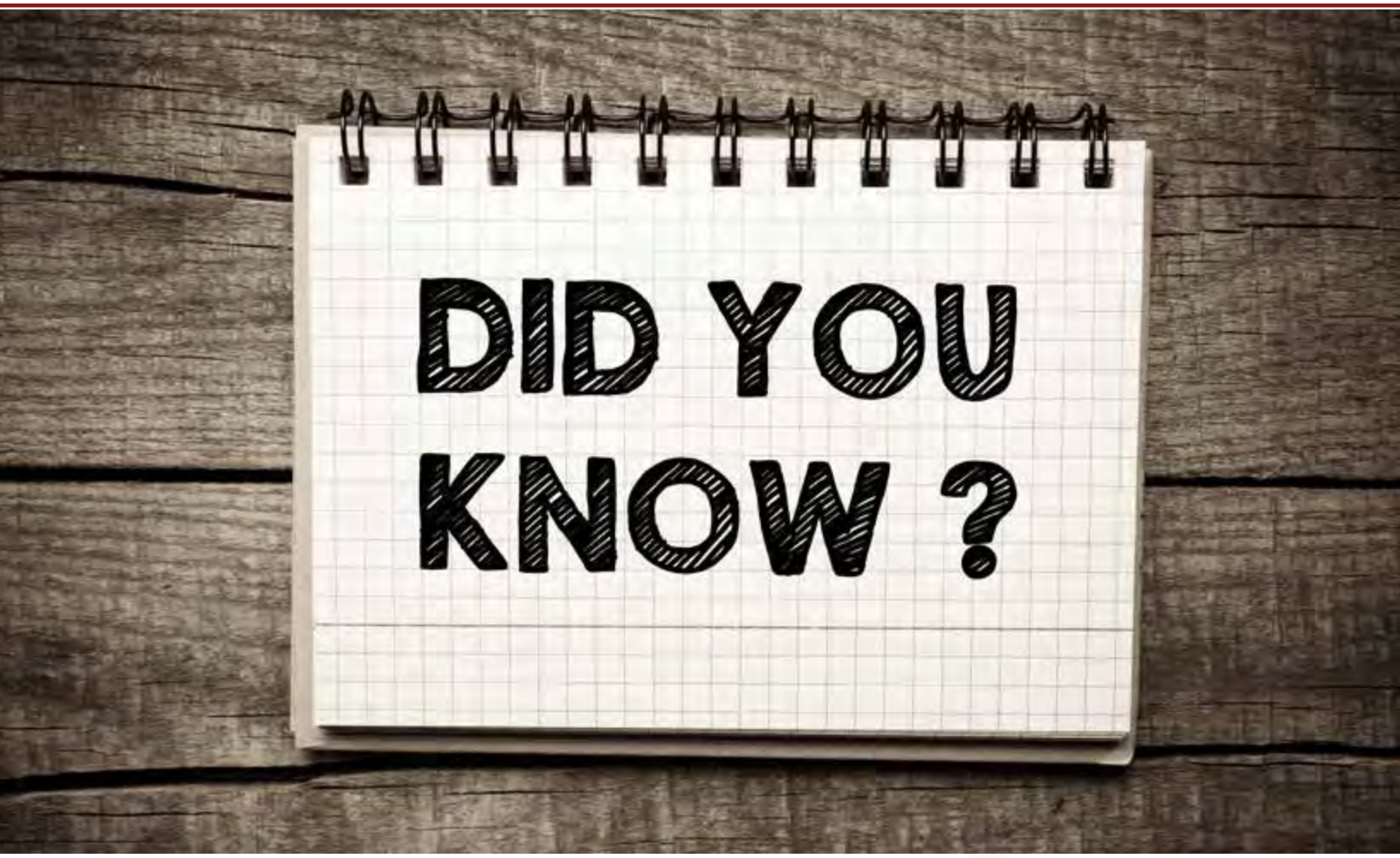

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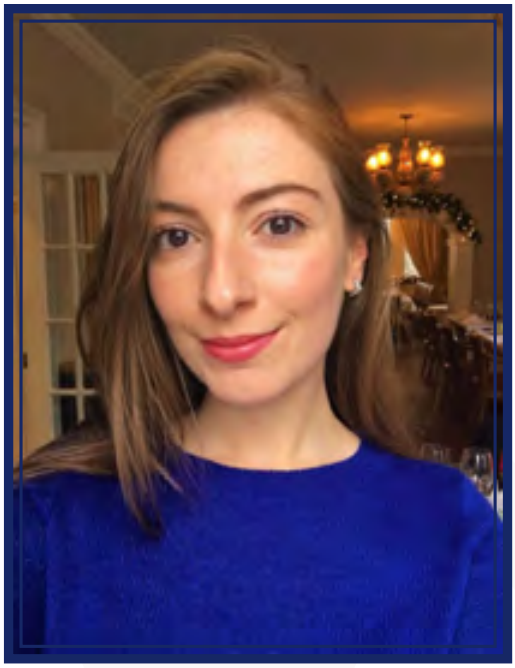
SPOTLIGHT: NADIA DEACETIS

My name is Nadia DeAcetis. I am 23 years old, from Aurora, Ontario. I am a graduate of the University of Toronto, where I obtained an Honours Bachelor of Science with a double major in Neuroscience and Human Biology. Following my undergraduate degree, I studied at the Michener Institute and received a Graduate Certificate in Intraoperative Neurophysiological Monitoring.



How did you hear about the Michener Institute Graduate Certificate in IONM and why did you enroll?

I came across Michener's IONM program while researching prospective graduate level education opportunities. I chose to enroll in the this program because I found the topic of Intraoperative Neurophysiological Monitoring to be fascinating and innovative. Moreover, I wanted to further expand my knowledge of neuroscience while studying its practical and medical applications.

Why would you recommend the Michener Institute Graduate Certificate in IONM?

I believe the program gives a great base of fundamental neuroscience and further builds upon these ideas to introduce the concept of multimodality monitoring. I found the program to be comprehensive and detailed, and the instructors are very knowledgeable in their field. Overall, it was an excellent experience.

How did you find out about the profession of IONM and what interested you in this career path?

I was introduced to the profession through my own personal research and by taking Michener's IONM program. I chose this career path so I would be able to apply my knowledge of neuroscience in a practical and meaningful way, as well as being on the front line of patient care.

What has surprised you about the field of IONM?

I believe IONM is an extremely useful and effective tool. It surprises me as to why there is still some hesitation among the medical community to embrace such technologies. I hope that as IONM gains exposure, there will be a positive shift towards its use in more medical centers.

What did you learn during your observation opportunity at SickKids?

I learned a great deal during my observership at SickKids. What stood out the most was how dynamic the operating room environment is, as well as how essential the neuromonitoring professional is to the operating team. Moreover, being able to see how the different modalities were used to enhance patient safety and post-operative function was very exciting.

SPOTLIGHT: MARK UKU

My name is Mark Uku. I was born in Nigeria and moved to Toronto, Canada at the age of 9. I was always a curious and inquisitive person which led me to pursue a degree in Biology at the University of Waterloo. After I graduated, I worked as a lab assistant at Estee Lauder. About a year later, I stumbled upon the Michener program on IONM. It piqued my interest so I enrolled. While continuing my IONM studies I started working as a production chemist at DSC. I found the IONM program's depth and subject matter so interesting that I gladly continued. Two years and a graduate diploma later, I now have a burning passion for IONM and I am actively looking for opportunities to practice in the field I fell in love with.

How did you hear about the Michener Institute Graduate Certificate in IONM and why did you enroll?
A few years ago, my family doctor diagnosed me with a slight case of idiopathic scoliosis. While the curve is minimal, the topic alone was enough to kindle my interest in the condition. A few hours later down the rabbit hole of the internet I discovered the Michener program! I quickly enrolled out of pure curiosity and have not looked back ever since.

Why would you recommend the Michener Institute Graduate Certificate in IONM?
I would recommend the Michener Institute program because it does a great job in delivering a wealth of information in easily understandable sections. The lecturers are knowledgeable and enthusiastic, the content is easily absorbed, and subject matter is fascinating.

How did you find out about the profession of IONM and what interested you in this career path?
I found the IONM profession shortly after I discovered the program. I have always wanted to work in healthcare and IONM has given me a more concrete path towards that goal.

What has surprised you about the field of IONM?
What surprised me about IONM was the amount of information a skilled neuromonitorist could ascertain from signals. A skilled neuromonitorist could differentiate between signals and artifacts, deduce the depth of anesthesia, or even tell if the patient may have an underlying condition.

What did you learn during your observation opportunity at SickKids?
From my observation at SickKids, I learned that neuromonitoring requires a lot of preparation and set up before hand. Cooperation and trust between all members of the surgical team is also key for a successful surgery. Communication is especially important between the surgeon, anesthesiologist, and neuromonitorist.

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Even published articles can have serious flaws:

Lessons learned from critical review of the literature

An interesting topic in intraoperative neuromonitoring (IONM) these days is the use of facial motor evoked potentials (FMEP). Obtaining MEP from facial muscles is, in principle, no different than MEPs derived from muscles of the upper and lower limbs. Transcranial electrical stimulation is used to activate descending motor fibres resulting in synaptically mediated compound motor action potentials recorded from EMG electrodes inserted into target muscles. The FMEP technique possesses enormous potential for monitoring the facial nerve and its corticobulbar pathways. Initially described for use in vestibular schwannoma surgeries[1], FMEP also retains value during cerebral aneurysm procedures[2], microvascular decompression for hemifacial spasm[3], or any surgeries where elements of the facial nerve pathway may be at risk.

FMEP can be distinguished from routine MEP in the requirement for technical precautions necessary to validate a properly recorded evoked potential. As such, it should be considered an advanced technique in IONM. In their original description of the method Dong *et al.*,1 were careful to outline the use of the single pulse test to validate the FMEP recording. Electrical stimulation of the scalp can lead to current spreading to extracranial facial nerve segments which can be identified by the short latency CMAP following a single pulse stimulation test. In contrast, a valid FMEP recording will generate no CMAP with a single stimulation pulse but generally requires multiple stimulation pulses to elicit an FMEP with an on-set latency in excess of 10 ms. However, recent studies have identified another potential issue in validating FMEP recordings[4,5]. Namely, threshold or subthreshold peripheral facial nerve stimulation following the transcranial stimulation train can facilitate axonal depolarization following closely timed stimulation pulses; a facilitated axonal excitation. In other words, a negative single pulse test may not necessarily validate subsequent multipulse elicited FMEP as the facilitated axonal response may appear to have an appropriate latency of > 10 ms. Finally, a third complication for recording valid FMEP is the potential for volume conduction from other cranial nerve activated muscles. The two most common being potentials generated in the tongue volume conducting to orbicularis oris electrodes or the masseter muscle volume conducting to other facial leads. The key point being that the transcranial electrical stimulation may activate other cranial nerve pathways and compromise the fidelity of facial muscle recordings. With these caveats in mind, as well as other technical details, we will examine a recently published article featuring the use of FMEP.

Lessons learned from critical review of the literature

Predictive Value of Intraoperative Facial Motor Evoked Potentials in Vestibular Schwannoma Surgery Under 2 Anesthesia Protocols by Ling and colleagues[6] is a prospective study designed to examine the diagnostic efficacy of FMEP under a total intravenous anesthesia or a combined volatile-propofol anesthesia. The strength of this study lies in its goal to assess the ability of FMEP to predict postoperative outcomes. The use of receiver operator curves to determine the ratio of final FMEP amplitude to baseline, while not new[7], is valuable data for IONM practitioners utilizing FMEP monitoring. The Ling *et al.*[6] series showed that a final-to-start FMEP amplitude ratio of 77% predicted good short term facial nerve function and 57% FMEP ratio predicted good long term function.

While the FMEP cutoff ratios are important information, there are some serious problems in the manner in which the authors report FMEP related data. In their methods the authors report using two different commercially available IONM workstations. The Endeavor device delivers 500 µs stimulus pulses for FMEP generation whereas the Cascade stimulator delivers 75 µs stimulus pulse widths. If the authors merely compared the FMEP amplitude ratios than these stimulus differences would not be important. Thus, Table 1 reveals a glaring technical oversight: the authors report baseline FMEP parameters that include mean stimulation intensity (in Volts). The authors have failed to consider the differences in applied stimulation when 500 or 75 µs stimulus pulse widths are used. The mean baseline stimulation intensity (and the reported range) are meaningless as a 500 µs stimulus pulse width is likely to achieve a FMEP with lower voltage than that needed using 75 µs. Instead, calculating the charge delivered would have factored in the differences in stimulus pulse widths used and allowed more meaningful data. This critical oversight is extended to Table 3 where details are compared between the anesthetic arms of their study. How many patients in each anesthetic arm were monitored using 500 or 75 µs pulse widths? Obviously mean stimulation intensities between TIVA and the volatile group are meaningless. Did the FMEP obtained using 500 µs pulse widths produce larger amplitudes? Or affect the latencies? The mean latencies reported in Table 3 of 11.2 ms are certainly less than 13 ms reported by Dong *et al.*[1]. This is disappointing, as the reader is left questioning the authors' technical acumen and less experienced practitioners may fail to notice these errors and repeat them.

To their credit Ling *et al.*[6] have observed the single pulse precaution outlined previously[1] and they show this in their Figure 1. In addition, they also obtain EMG data from multiple facial muscle channels as well as the masseter muscle. Curiously, the FMEP data is only obtained from the mentalis muscle so they limit their chances of detecting volume conducted responses or obtaining information from different portions of the facial nerve. Moreover, with recent observations that subthreshold current spread may lead to "false" FMEP[4,5] the authors appear to have not considered this impact on their study data as there is no mention in the paper of this. This is particularly important when stimulus pulse widths of 200 – 500 µs are used

Lessons learned from critical review of the literature

for FMEP acquisition as shown in the studies of Tellez *et al.*[4] and Urriza *et al.*[5]. Because of this, the onus is on the IONM practitioner using FMEP to demonstrate that subthreshold facilitation is not occurring and influencing the results. This is particularly so when stimulus pulse widths of 500 µs are utilized such as in the Ling *et al.*[6] study. My own unpublished results suggest that peripheral facial nerve facilitation does not occur when using stimulus pulse widths of 50 or 75 µs except in patients with hemifacial spasm. Until this is confirmed FMEP recordings must be carefully validated to ensure their legitimacy.

In Table 4 the authors display various characteristics in patients with satisfactory facial nerve function with those having unsatisfactory function (HB grade < 3) at discharge and at last follow up. What is entirely confusing is that FMEP data is included in the last follow up column. This needs clarification as it appears at first glance that new FMEP data were collected for the last follow up. After some deliberation it becomes evident that patients recover to satisfactory function by the last follow up thus shifting their FMEP data accordingly and generating new mean data. Once this is realized a significant difference in FMEP amplitudes is revealed between the satisfactory group and the unsatisfactory group. This is an interesting find but sadly is not discussed.

The paper by Ling *et al.*[6] has some merits but, in general, readers should be aware of some surprising errors that escaped the peer review process. Going forward, researchers interested in FMEP need to address the peripheral nerve facilitation issue, as well as, begin to combine FMEP data with free running EMG data. To be fair, Ling *et al.*[6] did combine one record of free running EMG with a simultaneously recorded FMEP, but this needs to be explored further. This is particularly so when EMG remains quiescent during most of the procedure. Comparison of the EMG sensitivity and specificity with FMEP data in their series would have made a new and valuable contribution to the literature. Because free running EMG is considered the gold standard for facial nerve monitoring more data is needed to bolster the claim that FMEP, in practice, are worth the effort.

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REFERENCES

1. Dong CJC, MacDonald DB, Akagami R, Westerberg B, AlKhani A, Kanaan I, Hassounah M. Intraoperative facial motor evoked potential monitoring with transcranial electrical stimulatin during skull base surgery. Clin Neurophysiol. 116 (2005) 588-596.

2. Zhang M, Zhou Q, Zhang L, Jiang Y. Facial corticobulbar motor-evoked potential monitoring during the clipping of large and giant aneurysms of the anterior circulation. J Clin Neurosci 20 (2013) 873-878.

3. Wilkinson MF, Chowdhury T, Mutch WA, Kaufmann AM. Analysis of facial motor evoked potentials for assessing a central mechanism in hemifacial spasm. J Neurosurg (2017) 379-385.

4. Tellez MJ , Ulkatan S, Urriza J, Arranz Arranz B, Deletis V. Neurophysiological mechanism of possibly confounding peripheral activation of the facial nerve during corticobulbar tract monitoring. Clin Neurophysiol 127 (2016) 1710-1716.

5. Urriza J, Arranz Arranz B, Ulkatan S, Deletis V. Integrative action of axonal membrane explored by trains of subthreshold stimuli applied to the peripheral nerve. Clin Neurophysiol 127 (2016) 1701-1709.

6. Ling M, Tao X, Ma S, Yang X, Liu L, Fan X, Jia G, Qiao H. Predictive value of intraoperative facial motor evoked potentials in vestibular schwannoma surgery under 2 anesthesia protocols. World Neurosurg 111 (2018) E267-E276.

7. Acioly MA, Liebsch M, Carvalho CH, Gharabaghi A, Tatagiba M. Transcranial electrocortical stimulation to monitor the facial nerve motor function during cerebellopontine angle surgery. Neurosurg 66 (2010) 354-362

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INTRAOPERATIVE CORTICAL MOTOR MAPPING USING SUBDURAL GRID ELECTRODES IN CHILDREN

Synopsis of recent publication

Samuel Strantzas, MSc, DABNM
Associate Clinical Neurophysiologist
SickKids, Toronto, ON

Epilepsy surgery involves risk when resection of epileptogenic foci are in close proximity to eloquent areas, such as the motor cortex. As a result mapping the cortex accurately plays an important role in surgical planning and preventing post-operative motor deficits. In this study, Jain *et al.*[1] retrospectively reviewed the use of intra-operative motor mapping in pediatric patients through subdural grids using high frequency "train-of-five" stimulation (IODCS-grid), with regard to feasibility and safety. The mapping data obtained was compared to the more conventional practice of using a ball-tipped probe with similar high frequency stimulation (IODCS-probe), and also compared to extra-operative mapping through the grid (EODCS-grid) using the traditional Penfield stimulation technique.

The study was performed in a single pediatric centre and intra-operative motor-mapping (IODCS-grid and IODCS-probe) was performed in 20 patients. EODCS-grid was performed in 17 patients. The mean age at the time of mapping was 11.7 years with a range of 3.5 to 17.1 years. IODCS-probe was performed prior to the implantation of the subdural grid delivering a high frequency (ISI=1.1ms, 909Hz) train of 5-7, 50μs pulses. Once the grid was implanted, IODCS-grid was performed using similar stimulus parameters as IODCS-probe. Myogenic responses were recorded from the contralateral orbicularis oris (OO), deltoid (DE), extensor digitorum communis (EDC), first dorsal interosseous (FDI), tibialis anterior (TA) and abductor hallucis (AH). EODCS-grid was performed 3 days after the grid implantation using the Penfield stimulation technique delivering a 50Hz train of 200μs pulses for 5-10 seconds. The results of motor mapping obtained by the three techniques were considered while planning the final resection.

Not surprising, the results of IODCS-probe and IODCS-grid mapping yielded similar results. Motor responses were more commonly obtained from the DE, EDC and FDI muscles, and stimulation thresholds were similar between the 2 methods ($p>0.05$). The thresholds were not influenced by the presence/absence of cortical malformation, involvement of rolandic cortex, by the lesion radiologically, and the surgical hemisphere. There was no relationship between motor thresholds and the age at the time of mapping. However, with increasing age, there was a decline in the motor thresholds. Any effects of anesthetics between patients was controlled using a total intravenous anesthesia (TIVA), and with the use of EEG to maintain a tightly controlled and constant depth of anesthesia.

When compared to external mapping the median number of body regions mapped with IODCS-grid was 3 and with EODCS-grid was 1.4 ($p<0.0001$). Only 9/17 externally mapped patients demonstrated 100% concordance between the common body mapped regions obtained from IODCS-grid or IODCS-probe. Also, there were

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more stimulation-provoked seizures with EODCS-grid vs IODCS-probe and IODCS-grid (6/17 vs 0/20). This is not surprising considering the total number of pulses delivered to the brain during EODCS-grid mapping is significantly higher than IODCS-grid or IODCS-probe (a total of 250-500, 200µs pulses vs 5-7, 50µs pulses) which significantly increases the total charge delivered. Similar findings have been published. Szelényi *et al*[2] reported direct cortical stimulation associated seizures occur in 1.2% using the train-of-five technique and significantly more frequently in 9.5% patients using the 60-Hz, Penfield technique (p=0.001). In addition, Usui *et al.*[3] have found that external mapping through a grid using high frequency stimulation in awake patients is feasible without inducing seizures.

The study demonstrates that IODCS-grid can be done safely in children. It may be preferable to EODCS-grid as it provided a greater degree of motor mapping information. It was found to be safe as no stimulation-provoked seizures were elicited, and no anaesthesia related complications were noted. It also obviated the need for patient cooperation for motor mapping.

REFERENCES

1. Jain, P., *et al,* Intraoperative cortical motor mapping using subdural grid electrodes in children undergoing epilepsy surgery evaluation and comparison with the conventional extra-operative motor mapping, Clinical Neurophysiology (2018). https://doi.org/10.1016/j.clinph.2018.07.022

2. Szelényi, A., *et al.,* Intraoperative risk of seizures associated with transient direct cortical stimulation in patients with symptomatic epilepsy. J. Clin. Neurophysiol. 2007, 24, 39–43.

3. Usui N., *et al.,* Extraoperative functional mapping of motor areas in epileptic patients by high-frequency cortical stimulation. J Neurosurg 109:605-614, 2008.

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