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Canadian IONM News

Official Newsletter of CANM

Contents

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CANM
CANADIAN ASSOCIATION OF NEUROPHYSIOLOGICAL MONITORING

Message from the President

Hi everyone,

A new year is upon us and one of the first things that comes to mind (of course) is our CANM memberships. So just a gentle reminder for those who have not renewed their CANM memberships, to please consider doing so; we are a small organization and everyone's support is very much appreciated.

I would also like to remind everyone to mark your calendar for CANM's annual symposium in Calgary, Alberta on September 14 - 15. This meeting is always well received and provides fantastic opportunities to learn about our craft and to meet your IONM colleagues. I highly recommend for those visiting Alberta for the first time to take the opportunity to venture into Banff National Park which is about 2 hours west of Calgary. It is truly a jewel of a place and I have fond memories of hiking, skiing and camping in those mountains. As luck would have it, September is the perfect time of year to visit Banff!

I recently stated that the IONM profession stands at a crossroads. This can be thought of in several ways but what's on my mind particularly is the pressure to establish evidence based practice in IONM. Obviously I have my own bias in this regard but supportive evidence for the use of IONM remains at a disadvantage because no randomized controlled trials have been done, and due to ethical considerations, are not likely to be done. So how can IONM be reasonably evaluated? One method is to review the available literature and assess the strength of the evidence and make informed judgments on the published data. This has many weaknesses including lack of universal training amongst practitioners, different monitoring methods employed for similar surgical procedures and what, if any, interventions are initiated in response to IONM alerts.

Not so long ago I would have read questionable studies in IONM and merely disregarded them. However, I now realize that bad data can be interpreted as ineffectual IONM in general. Most IONM practitioners would recognize this misconception but often impressions which disfavour the use of IONM arises from people who do not possess expertise in neuromonitoring and thus the ability to critically evaluate it. Fortunately we do have the expertise and the ability to identify poor data or inappropriate criticism.

In this newsletter we are fortunate to have contributions from several contributors who will discuss CUSA tip stimulators, remote neuromonitoring and anesthesia's relationship with IONM. In addition, I will outline two recent publications which provide examples of poor IONM interpretation and the lack of balanced data evaluation. It is up to us to identify published works that have faulty conclusions, but at the same time, be prepared to acknowledge good studies, regardless of how these may affect our profession.

Sincerely,

Marshall Wilkinson BSc (Hon), MSc, PhD
Neurophysiologist
Section of Neurosurgery
Health Sciences Centre, Winnipeg, MB

Take advantage of our membership offers by renewing your CANM Membership!

Hello Neuromonitoring professionals!

I'd like to invite you to join CANM, the Canadian Association of Neurophysiological Monitoring representing IONM professionals in Canada and help shape the future of IONM in Canada.

In Canada and internationally, the IONM profession faces many crossroads. How do we prepare ourselves for these challenges and potential changes? The answer is through knowledge to address erroneous criticisms and education to place us in positions to offer appropriate IONM services and interpretation. CANM provides formal IONM education (through the Michener Institute, annual symposium, CANM talks webinars and CANM newsletters) but also informally via interactions with fellow IONM colleagues.

The Graduate Certificate in IONM Program, a partnership between CANM and the Michener Institute, provides excellence in IONM training on an easily accessible web-based platform. A major advantage of CANM membership is that full members can register for individual courses without needing to register for the Graduate Certificate Program. For more information please visit: www.canm.ca/education.html CANM members will continue to receive a discounted rate at the annual symposium and priority registration for CANM talks.

In addition to the advantages outlined above, being a CANM member connects you to your professional community. This union is not just a social one but an opportunity to tap into the collective wisdom and experience of other IONM professionals. Collectively, we all gain from participation in the IONM community. We learn, we form collegial relationships, and we improve patient care through shared expertise. Consider the opportunities provided by being a CANM member and sign up today at: www.canm.ca/membership/register

I extend a gracious and advanced thank you to all who support IONM in Canada through membership in CANM. Your contribution is greatly appreciated.

Sincerely,

Marshall Wilkinson, BSc (Hon.), MSc, PhD,
Neurophysiologist
Section of Neurosurgery
Health Sciences Centre
Winnipeg, MB

CLICK HERE
to sign up today

Welcome

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This year's program application deadline is **June 22, 2018**.

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Remote Presence Monitoring

Remote monitoring or remote interpretation of neuromonitoring is widespread in the United States of America but has a generally negative perception in Canada. Remote monitoring is used when the expert, able to provide detailed interpretation and interact with the rest of the surgical team is not able to be present in the operating room. Most (if not all) of the companies making IONM equipment allow for remote monitoring over the internet. Remote monitoring may be either by screen transfer or DCP (either the remote person is able to see exactly the screen that the in-room person sees or is able to independently view screens). No instances (to my knowledge) allow the remote monitor to apply stimulation, or alter settings. When the in-room person uses either a microscope or overhead (or head-mounted) cameras to show on screen the surgical field, the remote person views the same field. In the absence of that view, a 'web-cam' may be used to allow a view of the operating room. Although the field of view of modern webcams is improving, as is the resolution, they still remain far short of direct vision. There is limited, if any, transmission of audio information. Communication between the remote and in-room individuals is typically through a 'chat' session or text messages on cell phones.

The use of telemedicine is increasing throughout Canada and other areas of the world. Such technologies are approved for use in many areas of medicine such as assessment of stroke, or even psychological assessments and therapies. As telemedicine has evolved a further area, remote presence medicine, has arisen. This technology uses more advanced technologies to allow more than just visual communication. These devices are as varied as most other technologies, and have been used to mentor surgeons, remotely programme neuromodulation devices, amongst other applications.

Dr. Ivar Mendez (*shown in photo*) has been a pioneer of the use of these devices in Canada, and is widely sought for advice on remote presence medicine internationally by governments and NGOs. Since his move to Saskatoon from Halifax we have been deploying and using remote presence devices across the province of Saskatchewan. With nearly 652 thousand kilometres and a population of just over 1 million (over half of whom live in 2 major urban centres) there are many remote communities. In the operating rooms in Saskatoon we have a Vantage system from InTouch Health (www.intouchhealth.com), while in Regina we use a RP7i from the same company. These devices are at the larger end of the devices in use throughout the province. The RP7-i is

Figure 1 *illustrates the classical (US-based) version of remote monitoring with an individual in the operating room, and transmission to a MD at a remote site. (images courtesy of Google)*

driven independently by the remote operator and has sensors to prevent inadvertent collisions. The angle and focus of the camera is controlled by the remote operator. The screen displays a view of the remote operator. The Vantage system requires positioning by someone in the operating room and has 2 high quality cameras that can be directed remotely. One camera is positioned on the main body of the system whilst the second is located on a boom that can be placed over the surgical field.

Why might these devices play a role in remote monitoring? The ability to control both audio and visual information independently of the person in the room is probably the most critical difference between standard remote monitoring and the addition of remote presence. Additionally, the remote user is able to show images, including with annotation if needed, to the in-room team. In our experience to date the device has been useful for training of staff, allowing them to be more independent than having a mentor in the room directly. It also allows an expert to be 'present' when they can not physically be in the room. This clearly has implications in remote monitoring, but we are currently working on situations in which devices are deployed in remote health care settings overseas where there is no option for neuromonitoring.

We use devices from InTouchHealth but many other devices are available from other companies. This is not intended to recommend any particular company or range of products.

Jonathan Norton, PhD
Assistant Professor and Clinical Neurophysiologist
Department of Surgery, University of Saskatchewan

Figure 2 *shows a variety of remote presence devices as deployed throughout Saskatchewan.* ***Bottom right*** *is the dual camera Vantage system.* ***Top middle*** *is the RP7-i deployed in a remote community with a pediatrid consultation taking place, where Dr. Holt (pediatric ICU physician) is driving the robot from Saskatoon and tests are assisted by a nurse practitioner on-site. In the top right image Dr. Mendez holds the smallest system, the so-called* **"Dr in a box"**. *In the* ***top left*** *a demonstration of remote ultrasound is shown (using my office as the remote site).*

Perspectives on Subcortical Motor Mapping:
Part 1 - Methodology

François D. Roy PhD, CNIM
Department of Surgery and Neuroscience and Mental Health Institute
University of Alberta, Alberta Health Services, Edmonton, Alberta.
Email: Francois.Roy@ahs.ca

Introduction

I would like begin by first acknowledging the landmark studies of Drs. Kamada (2009), Szelenyi (2011), Raabe (2014), Bello (2014), Shiban (2015a,b) and many more that have led to the advancements in the field of subcortical motor mapping during glioma resections. These approaches have forged new paths for intraoperative physiology by providing opportunities for real-time motor mapping during the course of a surgical resection. While there have been many notable papers on the topic, including the more recent review by Schucht et al. (2017), the following 3-part article was written to convey a few of my personal thoughts on the subject matter.

Recordings

In Edmonton, Alberta we have the privilege of monitoring craniotomies in an intraoperative MRI (iMRI) suite. This environment has inherent technical challenges, and I expect that our current protocol will evolve with further advancements in MR compatibility and safety. Indeed, there is even recent work showing that subdermal needles can remain on a patient during an intraoperative MRI scan, which has the potential to greatly simplify our IONM setups (see Darsey et al. 2016; Sarnthein et al. 2016; Breitkopf et al. 2017).

For monitoring brain tumors in the iMRI suite, we use a combination of subdermal needles (Rochester Electromedical), MR-compatible electrodes (Rhythmlink, 3 Tesla) and surface electrodes. We monitor motor evoked potentials (MEPs) using MR-conditional cup electrodes placed on the target side over the biceps-triceps, extensor-flexor carpi radialis, quadriceps and tibialis anterior-medial gastrocnemius. These electrodes are applied using Nuprep, Ten-20 paste and mefix prior to surgery. Most electrodes are jumped (denoted by '-') to increase MEP coverage (see also Carrabba et al. 2008). We use subdermal needles in the mentalis, abductor pollicis brevis-abductor digitimi minimi and abductor hallucis-extensor digitorum brevis owing to their higher skin impedances. If the face is at risk, additional electrodes are added in the orbicularis oculi and tongue. We monitor upper and lower limb SSEPs on the target side (i.e. contralateral to the incision) and record the evoked potentials and EEG using straight ribbons placed near Fz, Cp3, Cp4, Cz, Oz and C2-spine (Rochester Electromedical). It remains our practice to remove all subdermal needles before an intraoperative scan, and then replace the needles in the face and limbs following the scan, as needed.

TcMEP monitoring

We perform transcranial MEP (TcMEP) monitoring to complement our mapping protocol to estimate corticospinal tract (CST) integrity and also evaluate the suitability of the anesthetic/physiological conditions for direct cortical and subcortical MEPs (dcMEPs and scMEPs). We place MR-conditional electrodes around the craniotomy site targeting C1-C2 (leg) and C3/4-Cz (arm). We evaluate TcMEPs in the opposite hand and foot to estimate the penetration of current in the brain (*see Figure 1 in Part 3*). For more superficial activation closer to the level of the cortex, TcMEPs should be elicited exclusively on the patient's contralateral side. Spread of TcMEPs to the ipsilateral 'control' muscles is more indicative of activation of CST fibers closer to the level of the internal capsule and/or the pyramidal decussation, which would be more predisposed to false negative results.

dcMEP mapping and monitoring

We map the motor cortex using anodal stimulation by means of a monopolar probe (2.3 mm ball; Neurosign) or a strip electrode (4-contact; Dixi Medical) under total intravenous anesthesia. During cortical stimulation, the rate of stimulation does not exceed 0.5 Hz to mitigate the risk of an intraoperative seizure, though slower rates are useful. We use an MR-conditional electrode placed at Fpz to serve as the return electrode (i.e. cathode). This electrode is often more lateral owing the site of the surgical exposure, which in some instance, can lead to a blink reflex in the orbicularis oculi (*see Contamination from blink reflex* in Part 3).

We use a train-of-5 stimuli with a pulse duration of 500 µs owing the improved 1 mA : 1 mm linearity when using 500-700 µs pulses for subcortical MEPs (see Shiban *et al.* 2015a). We use a 4.0 ms interstimulus interval (ISI) or 1-2 ms when mapping the face to shorten the duration of stimulus artefact. For mapping purposes, the stimulation intensity is typically increased to 25 mA. Motor thresholds are generally around ~10 mA in adults and are typically lowest in the upper extremity and higher in the leg and face. In some patients with high thresholds, it can be useful to examine both polarities since cathodal stimulation will sometimes yield a lower threshold, for instance, when targeting the leg motor cortex.

scMEP mapping

Subcortical mapping (scMEP) is performed using a monopolar probe or the tip of the ultrasonic aspirator (CUSA or SonaStar; *see Figure 1*). I would encourage the reader to view Part 2 for more information on the technical requirements for mapping using an ultrasonic aspirator. Subcortical mapping is done using cathodal stimulation. As a general approximation, the relationship between the scMEP threshold and distance from the corticospinal tract is 1 mA : 1 mm. This means that if the scMEP threshold is 5 mA, then corticospinal tract fibres are approximately 5 mm away. When providing dynamic testing using the ultrasonic aspirator, we typically begin at 20 mA to provide a positive control, then progressively decrease the current in a stepwise fashion. We adjust the rate of stimulation based on the relative distance. We typically begin at 0.5 Hz when stimulating at 11-20 mA, then 1 Hz at 6-10 mA and then 2 Hz when the stimulus is ≤ 5 mA. This allows us to improve the spatial and temporal sampling as the surgical resection approaches CST fibres.

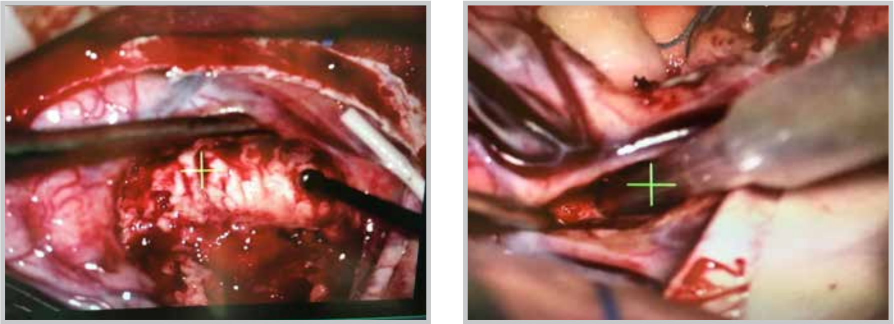

Figure 1. **Left**, *Image shows the dcMEP monitoring with the strip electrode placed under the dura and scMEP mapping with the monopolar probe.* **Right**, *Image shows continuous real-time scMEP mapping with the electrified tip of the aspirator.*

Stimulator connections

We map cortical and subcortical structures using a constant current stimulator (Cadwell, ES-IX). The return electrode (i.e. Fpz) is connected to the negative inputs on channels 3-8 and the low stimulus channel (*see Fig. 2*). We use a 4-channel strip electrode connected to the positive input on channels 5-8 (i.e. for contacts 1-4). The monopolar probe is connected to channel 4, which is then bridged to the low stimulus channel for added stimulus options. The cable from the ultrasonic aspirator is connected to the low stimulus channel. Subcortical mapping is done either with the monopolar probe or ultrasonic aspirator using the low stimulus channel owing to its better resolution at the lower stimulus intensities (i.e. < 5 mA).

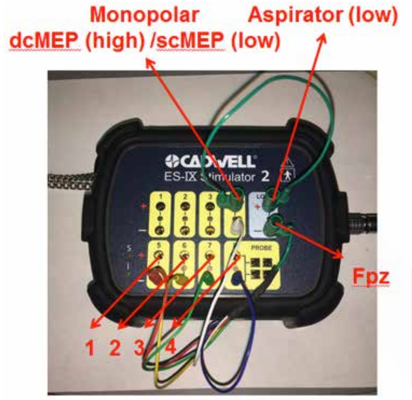

Figure 2. *Stimulator connections for motor and subcortical mapping. Numbers 1-4 represent connections to the strip electrode.*

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Perspectives on Subcortical Motor Mapping:

Part 2 - Methodology for continuous subcortical motor mapping using ultrasonic aspirators

François D. Roy PhD, CNIM
Department of Surgery and Neuroscience and Mental Health Institute
University of Alberta, Alberta Health Services, Edmonton, Alberta. Email: Francois.Roy@ahs.ca
* A version of this article appeared in Roy (2016)

Background

Monopolar train-of-five stimulation can be used during brain tumor resection to estimate the distance between the margins of the resection cavity and the corticospinal tract fibres (Kamada *et al.* 2009; Shiban *et al.* 2015a). The motor threshold-to-distance relationship can be approximated as 1 mA : 1 mm for most distances using cathodal stimulation with 0.5 and 0.7 ms pulses, though the distance may be an overestimation at the lowest stimulation intensities. This nonlinearity is discussed by Shiban et al. (2015a). To supplement this approach, subcortical mapping can be administered using an insulated suction (Raabe *et al.* 2014). This approach improves the mapping accuracy as it delivers current at the exact site of the resection and can be performed continuously. This method is most relevant when identifying low stimulation thresholds < 5 mA whereby the distance between the resection cavity and the corticospinal tract fibres are likely within 5 mm. While some surgeons may favour an ultrasonic aspirator during glioma resections, recent methodological advancements have shown that subcortical motor mapping is feasible with the Misonix SonaStar (Shiban *et al.* 2015b), Söring handpiece (Söring GmbH; Boëx *et al.* 2016) and CUSA Excel+ cavitron ultrasonic surgical aspirator (Integra LifeSciences; Boëx *et al.* 2016). While not all hospitals will have access to the same ultrasonic aspirators, the multitude of stimulating options provides some alternatives for each neurosurgical group.

Methodology

Monopolar stimulation using the tip of the SonaStar is a straightforward approach as it only requires connecting the cautery cable to an electrical nerve stimulator rather than the intended coagulation device (Shiban *et al.* 2015b). This further requires converting the cable's banana connector into a touch-safe DIN connector. At this time, we have yet to examine the Söring system owing to its unavailability at our hospital. Subcortical mapping with the CUSA Excel+ is achieved by replacing the standard 36 kHz nosecone with a CUSA Electrosurgery Module (CEM; part number C6636, Integra LifeSciences). The lone pin located on the uncrowded end of the plug (*see arrow in Figure 1*), which is intended for the Valleylab Force FX electrosurgery device (Covidien, Ltd), is connected to the electrical nerve stimulator via a similar banana-to-touch-safe adapter. If the surgeon wishes to regulate the stimulation, then the ON time can be controlled using a button on the nosecone. This then requires connecting the plug's middle pin to the electrical stimulator. In general, we have preferred bypassing this option owing to the convenience of regulating all stimulation parameters from within the neuromonitoring system. While the literature indicates that the tip of the CUSA can break due to erosion during regular CEM coagulation, this is unlikely an issue during subcortical mapping owing to the low electrical currents administered during the stimulation. Further, it is conceivable that an

Part 2 - Methodology for continuous subcortical motor mapping using ultrasonic aspirators

ultrasonic aspirator can produce transient inhibition of fiber transmission, as evidenced by transient speech disturbances and the suppression of direct cortically and subcortically activated motor responses evoked by 60 Hz bipolar stimulation shortly after CUSA operation (Carrabba *et al.* 2008). While these issues might be less applicable to subcortical monopolar high-frequency train-of-five stimulation, these issues should nonetheless be considered.

Advancements in the field of subcortical motor mapping during glioma resection are continuing to emerge. These improvements will continue to help neurosurgeons carefully navigate these delicate structures and minimize the risks of motor impairments following surgery.

Figure 1. *Connection of the CEM nosecone (C6636, Integra LifeSciences) for electrical stimulation with the CUSA. The pin on the left (see arrow) is connected to the neuromonitoring system for continuous stimulation.*

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Perspectives on Subcortical Motor Mapping:

Part 3 - Discussion of potential issues and considerations

François D. Roy PhD, CNIM
Department of Surgery and Neuroscience and Mental Health Institute
University of Alberta, Alberta Health Services, Edmonton, Alberta. Email:
Francois.Roy@ahs.ca

Overview

Now that the specifics of our mapping protocol have been outlined, I will describe some of the more interesting considerations about subcortical motor mapping. These topics have been subdivided into several short sections for added convenience.

Dynamic scMEP testing

Effective scMEP monitoring is fairly straightforward in the absence of other tests. However, testing is much more complex when simultaneous cycling through the various IONM modalities. Roth et al. (2017) recommends testing dcMEPs every 20 seconds while temporarily pausing the subcortical stimulation with the CUSA. This breaks the continuity of the scMEP mapping, but invariably also serves a worthwhile purpose. At this point, we have not found an optimal solution given that simply increasing the amount of stimulation to the brain also has its drawback (i.e. seizures, limited attention capabilities of the monitorist, etc).

Pre-operative weakness

While it is well-recognized that pre-existing weakness will compromise MEPs, this can become more problematic when providing subcortical mapping over an affected area owing the presumed higher incidence of false negatives. In essence, if scMEPs are poor, then so could the 1mA : 1mm current-to-distance relationship. As an example, I have enclosed screenshots of a patient with poor TcMEPs and scMEPs in the leg (*Figure 1*). The TcMEPs in the target leg were only seen with deep CST activation as evidenced by the contralateral spread of activity to the opposite (control) hand. During subcortical mapping, small yet consistent scMEPs in AH were seen at 15 to 6 mA, but were absent < 6 mA. It is unclear whether this is because the CST fibers destined to the leg were ≥ 6mm away or because of impaired activation of the fibers at the low stimulus intensity. This patient fortunately experienced no new post-operative motor deficit.

scMEP thresholds in different muscles

At this point, it remains unclear whether scMEP thresholds vary between muscles. It would be intuitive to think that scMEP thresholds are consistent with dcMEPs (see Ng *et al.* 2010) or the TcMEPs monitored during spine surgery. However, the answer is less obvious. We have certainly observed a higher prevalence of scMEPs in the upper extremity, though we have also seen scMEPs as low as 1-2 mA in the face, tongue, forearm, hand and leg suggesting then that the minimum threshold and prevalence are two different features of scMEPs. In the face, we tend to observe most scMEPs in the tongue > mentalis > oculi, while the upper extremity forearm ≈ hand > biceps/triceps, and in the lower extremity foot ≈ TA-MG > quadriceps. Future studies, similar to what has been reported on dcMEPs during cortical mapping, are certainly warranted.

Part 3 - Discussion of potential issues and considerations

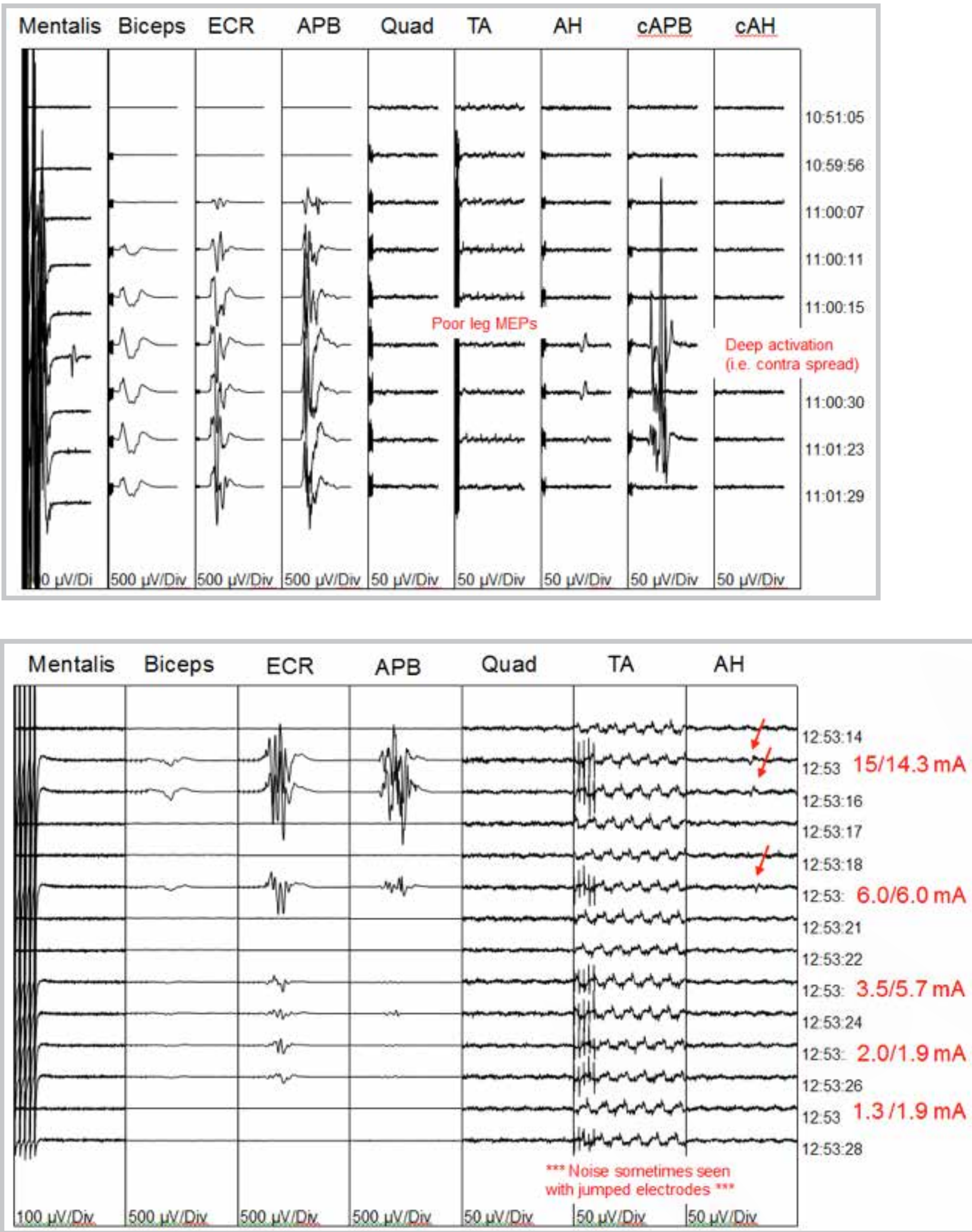

Figure 1. *Top, Patient with poor baseline TcMEPs in the leg. Small MEPs were seen in AH, but typically with concomitant activation of the contralateral hand (cAPB). Bottom, Subcortical mapping shows small, yet consistent scMEPs in AH from 15/14.3 to 6.0/6.0 mA. On their own, the small AH MEPs would be difficult to monitor without the larger MEPs seen in the upper limb. The stimulus intensity represents the specified/actual output from the stimulator.*

Mapping in pediatrics

The immaturity of the nervous system in pediatric population patients has a similar effect to pre-existing weakness and raises MEP thresholds. Roth *et al.* (2017) reported negative mapping in 36% of pediatric patients (4/11) during subcortical mapping with the tip of the CUSA. Note that this number may include both true and false mapping results. It noteworthy that the 7 patients with positive scMEPs were ≥ 6 yrs of age while the 3/4 patients with negative mapping were under the age of 6 yrs. It would seem plausible that this could relate to immaturity of the white matter tracts in these young patients, though the answer is

Part 3 - Discussion of potential issues and considerations

likely more complex. For instance, in a 3 year-old patient with cortically-based tumor, we observed a direct cortical dcMEP threshold of 27 mA in the forearm and hand, yet we could elicit scMEPs as low as 3.0/2.4 mA in the mentalis, forearm and hand with the tip of the SonaStar (see Figure 2). This data suggests that the maturity of CST fibers alone would not fully explain the phenomenon contributing to the heightened threshold in young patients.

Todd's paresis

Todd's paresis is a phenomenon whereby the CST can be unresponsive following a seizure. Plans et al. (2017) discussed a similar issue whereby a case was stopped shortly after a partial intraoperative seizure and the dcMEPs were lost and did not recover. This patient awakened without motor deficits. We had a similar occurrence whereby dcMEP stimulation at 12 mA triggered an intraoperative seizure. TcMEPs were unchanged following the seizure though the scMEP mapping was negative shortly thereafter. The patient then underwent an intraoperative MRI scan. Following the scan (90 mins post-seizure), we observed positive scMEPs in the hand and forearm with stimulation at 10 mA over the same site that had previously been negative. Indeed, an intraoperative seizure can augment stimulation thresholds and should be considered as a potential cause for transient negative scMEP mapping.

Transient inhibition of fiber transmission during CUSA operation

Carrabba and colleagues (2008) described an interesting phenomenon whereby the ultrasonic vibrations provided by the CUSA can temporarily interfere with cortical and subcortical responses. This was evidenced by transient speech disturbances and the suppression of motor responses using 60 Hz bipolar stimulation, potentially due to transient inhibition of axonal conduction. While we have yet to observe this phenomenon using train-of-5 stimulation, this issue should be considered in the context of perplexing mapping results.

Contamination from blink reflex

Given the feasibility of eliciting a blink reflex when delivering a train-of-5 pulses over the supraorbital nerve (see Deletis *et al.* 2009), it goes without saying that current spread from an Fpz anode on the forehead has the potential to elicit a blink. While pathways mediating the R1 component of the blink reflex differ from a corticobulbar MEP, the presence of a blink in the orbicularis oculi is a foreseeable confound when using stimulus intensities > 10 mA. To rule out the nature of a presumed blink, it is essential to show that the CMAP is strongly modulated as a function of the mapping location and not only the stimulus intensity. I would therefore recommend considering this crossed-activation when using a Fpz return electrode during motor and subcortical mapping.

Concluding remarks

While there is still much work that needs done to fully understand the parameter-space for scMEPs, I feel that we are moving in the right direction. With the advent of new capabilities to perform continuous subcortical mapping, alarm criteria are progressively being revised. At present, a subcortical MEP threshold of 3 mA appears to be a good stopping point given that the risks increase for threshold ≤ 3 mA. However values as low as 1-2 mA (see Figure 3) have been done safely when a complete resection can be achieved, particularly in the presence of a stable dcMEP (see Schucht *et al.* 2017).

Part 3 - Discussion of potential issues and considerations

Figure 2. *Top, Positive dcMEPs in the forearm and hand at 27 mA using the strip electrode (contact 3). Middle, Positive scMEPs responses are shown in the in the face, forearm and hand using the monopolar probe at 10 mA. Bottom, The minimum scMEP threshold was 3.0/2.4 mA using the tip of the electrified SonaStar, which is substantially different from the high dcMEP threshold of 27 mA.*

Part 3 - Discussion of potential issues and considerations

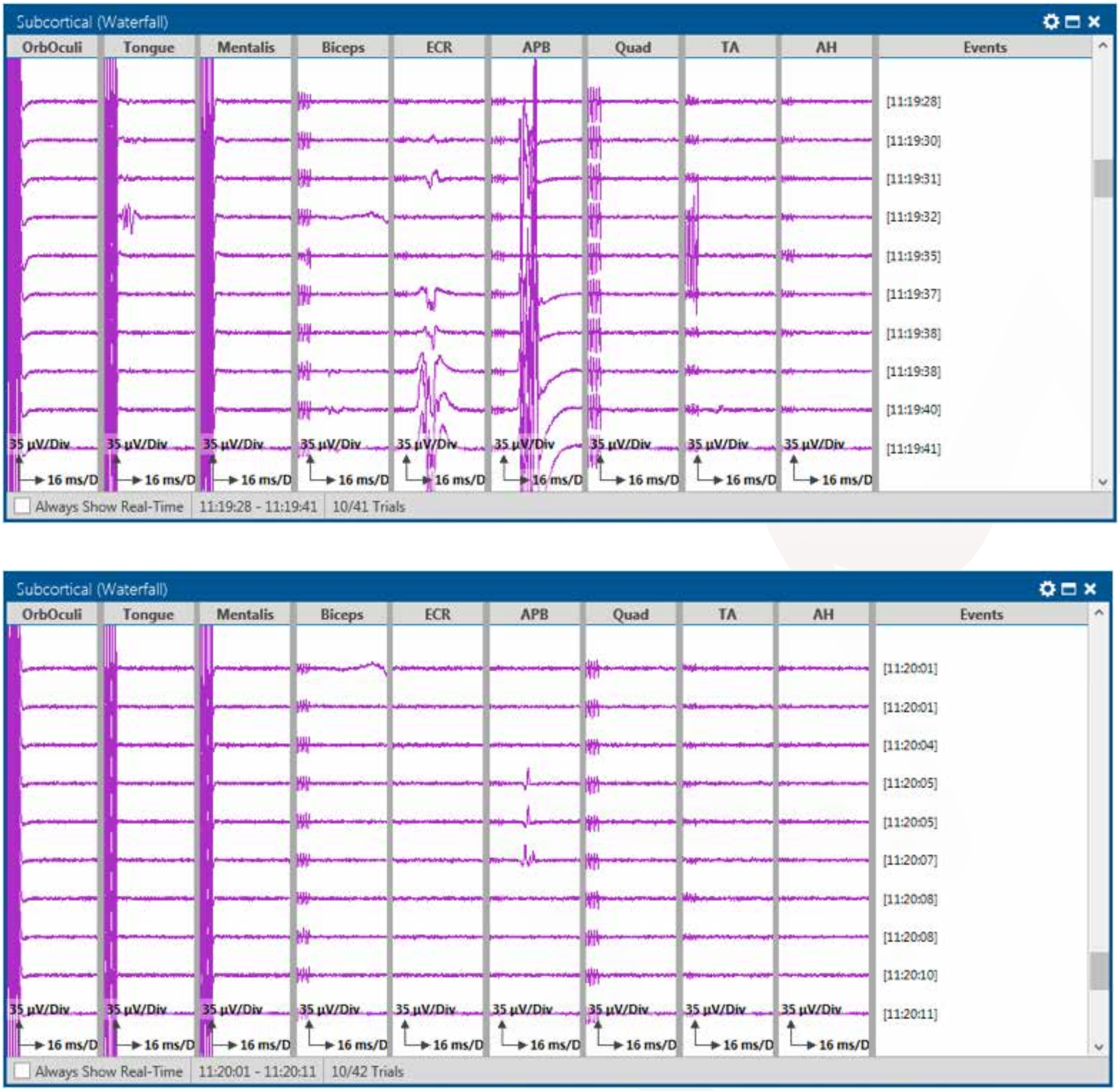

Figure 3. *Top, scMEPs were re-evaluated with the monopolar probe at 2.0 mA following CUSA mapping which yielded positive responses in the face and arm. Bottom, Small scMEPs were also seen in the hand at 1.0 mA. The patient experienced transient post-operative hand weakness and no new permanent motor deficit.*

Part 3 - Discussion of potential issues and considerations

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Spotlight
Chris Drummond-Main

My name is Chris Drummond-Main, age 38, from Ottawa, Ontario. I have a background in biology (B.Sc. in Biology from Carleton University) and neuroscience research (M.Sc. in Pharmacology and Toxicology from the University of Western Ontario). For the past 5 years I have been working in an epilepsy research lab at the University of Calgary, studying the electrical activity of neurons and mitochondria using patch-clamp electrophysiology. For part of this time, I have also been training in IONM at the Alberta Children's Hospital while completing the Michener Institute program.

How did you hear about the Michener Institute Graduate Certificate in IONM and why did you enroll?
When I first heard about the field of IONM, I began researching online and quickly found the newly-launched Michener program. I enrolled because I was interested in the field, and wanted a strong theoretical foundation to prepare me for practical training in the OR.

Why would you recommend the Michener Institute Graduate Certificate in IONM?
Being a very technical, knowledge-intensive field, I believe that a strong theoretical background is essential for IONM practitioners. The program provides a detailed background of sufficient depth and breadth as to prepare students for hands-on training in the OR. Being the only program of its kind in Canada, I also feel that it gives students a distinct advantage in the IONM job market.

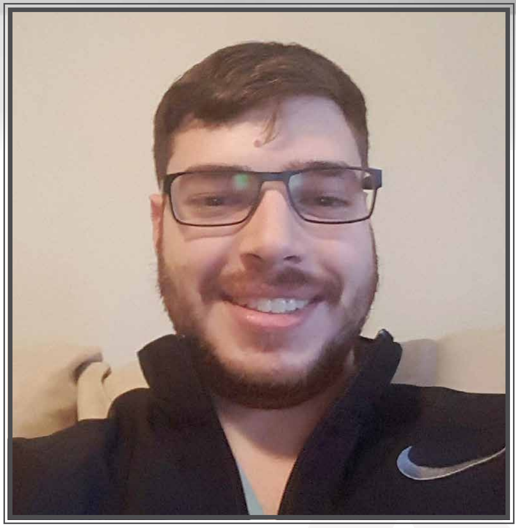
How did you find out about the profession of IONM and what interested you in this career path?
I had been curious about applying my background in electrophysiology to a more clinical setting when I heard about a fellow neuroscience researcher who had left academia to train in IONM. What interested me was the immediate, tangible value that IONM provides to patients, in contrast to the potential, future benefits that are the goal of laboratory research.

What has surprised you about the field of IONM?
I was surprised by how small the field is, and by how early in its development it is in Canada. Many people that I have spoken to have never even heard of IONM.

What is your overall impression of CANM's plan to develop a credential in IONM?
I think credentials are an important way to gain recognition for IONM, and to ensure practitioners are properly qualified. As the field grows in Canada and becomes more regulated, a nationally-recognized credential should become more and more important.

Why did you attend the 10th Annual CANM IONM symposium and what was your overall impression?
Being new to the field, I saw it as a great opportunity to network and learn about current issues in the field of IONM. I thoroughly enjoyed the symposium, and was impressed by the wide variety of educational backgrounds represented, and by the quality and high level of expertise of the speakers.

Spotlight
Gilaad Solomon Levy



My name is Gilaad Solomon Levy and I practice intraoperative neurological monitoring at Trillium Health Partners in Mississauga, ON. I did my undergraduate degree in Kinesiology at York University, and afterwards I got my diploma in Respiratory Therapy from Canadore College, in North Bay, ON. After graduating from college I found employment in outpatient EEGs, and from there I was fortunate enough to be hired at Trillium Health Partners (THP) where I received training in IONM. I'm currently enrolled in the Michener Institute Graduate Certificate in IONM program.

How did you hear about the Michener Institute Graduate certificate program and why did you enroll?
I heard about the Michener Institute graduate certificate program from my colleagues at THP, and through the IONM community in Toronto. I decided to enroll in the program to be as educated as I could be on IONM and neurophysiology.

Why would you recommend the Michener Institute Graduate certificate in IONM?
I would recommend the Michener Institute Graduate Certificate in IONM because it gives a concise base on the didactic knowledge of what is required to be a good neurophysiology practitioner.

How did you find out about the profession of IONM and what interested you in this career path?
I found out about the profession while employed at THP. A colleague retired and I was approached to fill the position.

What has surprised you about the field of IONM?
What has surprised me the most is how involved a neurophysiology practitioner is in providing data and warnings regarding patient safety, and in helping to guide the surgeons on the most appropriate actions to be taken.

What is your overall impression of CANM's plan to develop a credential in IONM?
I think it's a great idea that CANM is planning to develop a credential in IONM, although the CNIM certification is a good base, it does not directly relate to the Canadian healthcare system.

Why did you attend the 10th annual CANM IONM symposium and what was your overall impression?
I attended the 10th annual CANM IONM symposium to meet with other IONM professionals and learn as much as I could to improve the quality of monitoring that I provide.

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.

Laura Holmes

SickKids, Toronto, ON

Laura was invited to deliver a lecture at the Canadian Spine Society annual scientific conference in Banff, AB in February. She spoke about the importance of recognizing the pattern and timing of IONM signal changes so that appropriate interventions can be undertaken.

Francois Roy

University of Alberta Hospitals, Edmonton, AB

Francois demonstrated a novel way to shorten the stimulus artefact decay when recording D-waves by applying the "ABR" digital filter available on Cadwell workstations. For more information see Canadian IONM News 6.3.

David Holden

The Ottawa Hospital, Ottawa, ON

Dr. Houlden is enjoying some well-deserved time off after announcing his retirement from The Ottawa Hospital. While Dave may be leaving fulltime clinical IONM practice in Ottawa, there is no doubt that he will remain very active in the field of IONM.

Gilaad Levy

Trillium Health Partners, Mississauga, ON

Gil has successfully passed his Certification in Neurophysiologic Intraoperative Monitoring (CNIM) examination.

Karissa Rosen

Health Sciences Centre, Winnipeg, MB

Karissa recently wrote and passed her Canadian Citizenship exam!

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**

Teamwork and Communication in Healthcare

Communication failure has been and continues to be among the most common causes found in analyses of hospital safety events.

Most of the science that informs our understanding of communication failure in healthcare comes from research conducted in other contexts. Because of the availability of black box voice recordings and extensive investment in simulation, the aviation industry provides a rich source of data on how humans communicate. From this, we know that communication behaviors are specific and identifiable. They can and do happen spontaneously, but when the unexpected happens, the best communication requires specific training and reinforcement.

Tail section of United Airlines Flight 232 following crash.
https://en.wikipedia.org/wiki/United_Airlines_Flight_232

One of the most common types of communication failure identified in air disasters (and, as it turns out, in hospital safety event analyses) is the "monitoring and challenge" error. Effective monitoring/challenge interactions require four discrete steps to occur.

1. First, an individual must **perceive a threat** which needs to be escalated, be it an external threat, a change in status, a piece of new data, or a change in the pattern of the data being monitored.
2. Next, the individual must **decide if he or she will issue a challenge**. This is complex – the individual may second-guess him/herself, thinking: "What if I am wrong?" or "what if the person does not want to be interrupted?"
3. If they progress through that stage, they then must **determine how to communicate** it. Black box data reveals that there is a very wide spectrum in how directly people communicate. At one end of the spectrum are gentle hints ("I notice....") and at the other end, strong commands ("you need to…"). Very often, individuals "mitigate" their speech; in other words, they dial down the directness of their challenge in order to avoid being wrong or causing offence. This is particularly pronounced when there is a status or hierarchy gradient between the challenger and receiver.
4. The final step in the chain of a successful monitoring/challenge interaction is that the receiver of the challenge must be moved to **re-evaluate** the situation. This is also tricky. If the challenge is too gentle, the significance may be missed. If it is too commanding, the receiver may experience anger or embarrassment, which could result in less willingness to re-evaluate.

In the field of intraoperative monitoring, the relevance of this particular communication encounter is obvious. Encouragingly, there are many protective factors that allow for these interactions to be smooth most of the time. For example, members of the team are often familiar with one another. The expertise and input of the monitoring professional is recognized and it's expected that they are there

Teamwork and Communication in Healthcare

to monitor for problems. However, undoubtedly there are situations of unexpected or abrupt changes, uncertainty about the cause or remedy for the change, and complex dynamics between large teams dealing with high stakes cases. It is likely that formal training in specific teamwork and communication strategies, which has been proven to improve patient outcomes in surgical settings, could further enhance the success of monitoring programs.

At the **10th Annual CANM IONM Symposium,** I invited some of the participants to consider the following scenario: Suppose a patient has a particular allergy to a material commonly found in the operating room and this is discussed at the pre-operative briefing. Additional providers enter the case after the briefing, and you have a gut feeling they are missing key information and could cause harm to the patient. What do you do? This is not directly related to your role as a monitoring professional. You're feeling uncertain as to whether you understood the precautions accurately. And on top of that, the person you're considering questioning has been known to have a negative reaction to being questioned in the past.

Imagining this potentially difficult scenario, one must then come back to the principle that to achieve safety, everyone in the environment must feel completely accountable for the performance of the team and the outcome for the patient. This obliges us to speak up effectively. In a good safety culture, our concern will be taken seriously and we will be treated with respect even if our concern proves unjustified. Though healthcare has a long way to go before this is a consistent norm, hospitals endeavoring to apply robust high reliability and teamwork/communication training programs are achieving results and moving the needle in this challenging area.

Trey Coffey, MD FAAP FRCPC
Medical Officer for Patient Safety,
SickKids Associate Clinical Director,
Solutions for Patient Safety
Staff Paediatrician, Division of Paediatric Medicine
Associate Professor of Paediatrics,
University of Toronto
Core Faculty, University of Toronto Centre for Quality Improvement and Patient Safety (C-QuIPS)

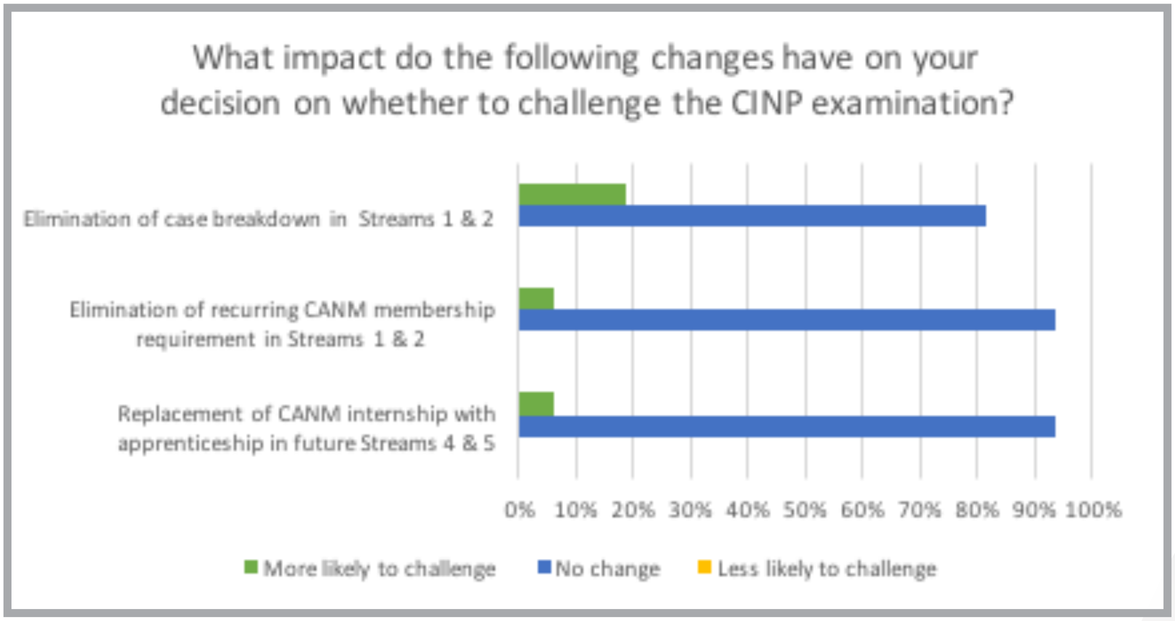
Feedback on the Suggested Changes to the Certified Intraoperative Neurophysiology Practitioner (CINP) Proposal

In the last issue of Canadian IONM News, the suggested changes to the Certified Intraoperative Neurophysiology Practitioner (CINP) proposal were introduced to the readership. These proposed changes were initially unveiled at the 2017 CANM IONM Symposium in September. Since that time, specific feedback on the proposed changes has been sought from the Canadian IONM community through an anonymous survey (n=16), roundtable discussion, email, and personal correspondence.

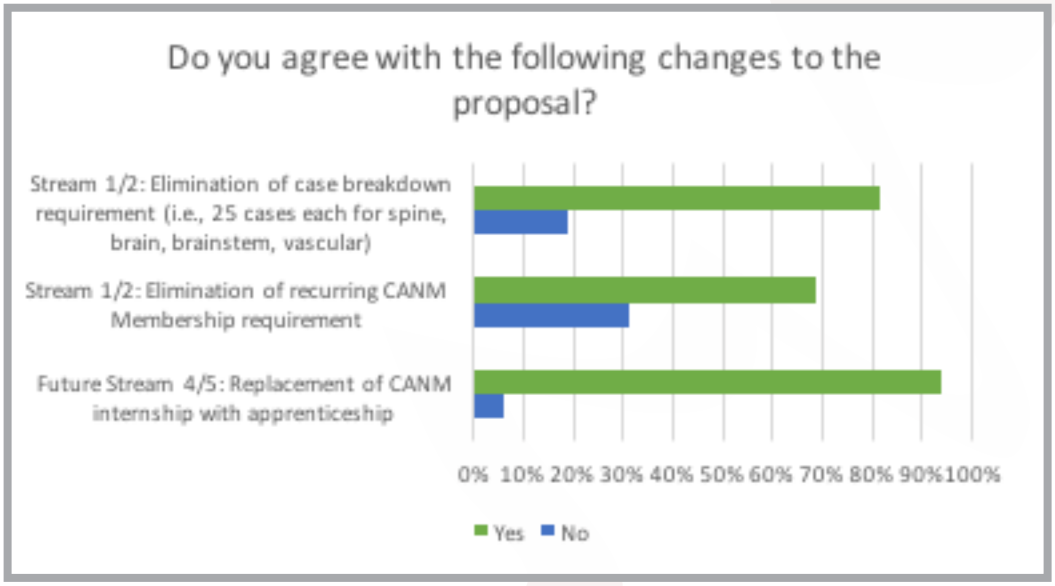
Suggested Changes to CINP Proposal

- **Elimination of CASE BREAKDOWN requirement (ie. 25 cases each of brain, brainstem, spine, vascular) - Stream 1 & 2**
- **Elimination of recurring CANM MEMBERSHIP requirement - Stream 1 & 2**
- **Replacement of CANM Internship with APPRENTICESHIP - future Stream 4 & 5**

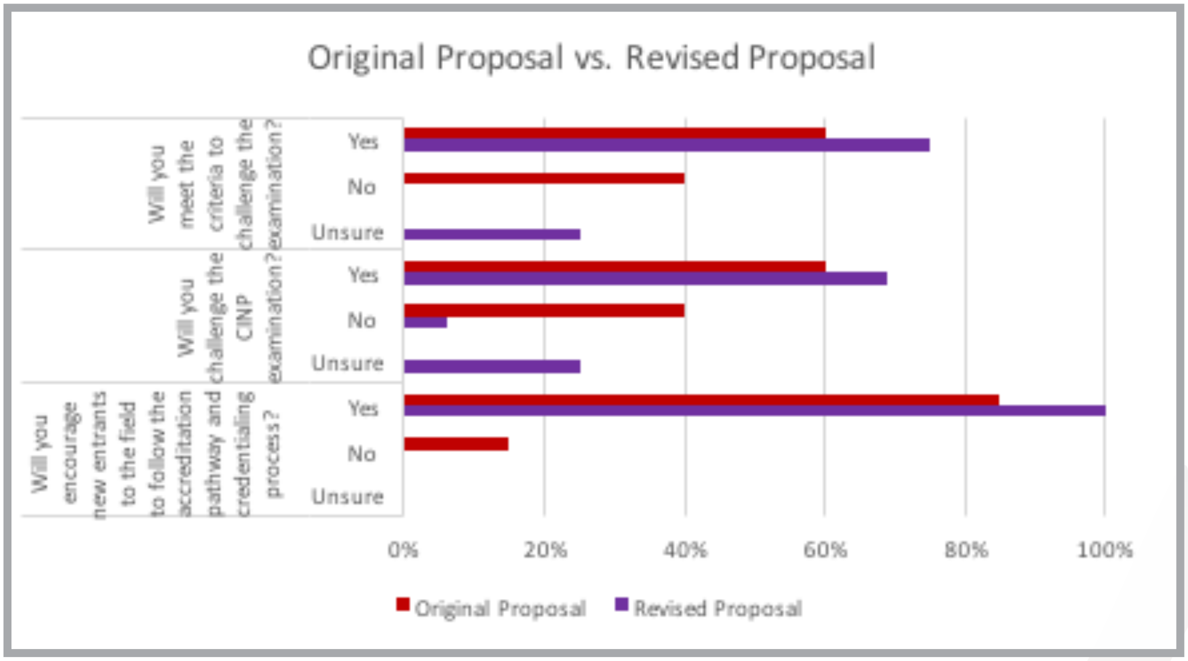
The intended purpose of the case breakdown requirement was to ensure that CINP candidates have a well-rounded background in a variety of techniques and skills that are required of a modern IONM professional. An unfortunate consequence of this requirement is that it presents a barrier to entry for many existing IONM professionals and the ability to meet the case breakdown requirement was a concern expressed by many experienced IONM professionals across the country. Many felt that the procedural mix at their institution put them at an unfair disadvantage and essentially disqualified them as a potential candidate who desired to obtain the CINP designation. By proposing to eliminate the case breakdown for experienced IONM professionals, more candidates will be eligible to challenge the examination process, as demonstrated by a reduction from 40% (n=20) in the original proposal to 0% with the revised proposal of survey respondents not meeting eligibility criteria within the next two years. Furthermore, nearly 20% of survey respondents state that they are more likely to challenge the CINP based on this change.



The 3 proposed changes did not negatively impact the respondent's own decision on whether to challenge the examination (0% less likely to challenge) and were largely neutral (81.25-93.75% no change) or positive (6.25-18.75% more likely to challenge). The vast majority of respondents also agreed with the 3 proposed changes with the most support garnered for the replacement of internship with apprenticeship (93.75%).



As with any anonymous survey, it is not possible to ascertain if the same respondents completed both the original and revised survey. However, the response to the proposed changes appears to demonstrate a positive shift in attitude toward the CINP proposal, with 100% of respondents now indicating that they would encourage new entrants to the field to follow the pathway. There was also an increase in the number of respondents who will or who may challenge the examination. This is an encouraging trend.



Some comments were received with respect to why those with CNIM certification or other educational preparation were not permitted to bypass the Michener Institute program requirement. Standardization of education is a key component of driving the IONM profession forward. For this reason, the Michener Institute Graduate Certificate in IONM features prominently in the proposed accreditation and credentialing pathway. Most candidates will be required to complete the Michener Institute program in order to be eligible for the CINP designation, although exceptions will be made for those holding D.ABNM certification (stream 3) or for experienced IONM professionals who were employed at Canadian institutions prior to the launch of the Michener Institute program in 2014 (stream 1). With the rapid evolution of the profession, it is no longer possible to rely on non-specific education (ie. nursing, electrophysiology technology, master or PhD degree) as a substitute for standardized, role-specific teaching and training. The online, asynchronous, part-time format makes the program easily accessible and both new and experienced IONM professionals will benefit from the vast amount of IONM-specific knowledge and background that is taught in the program. To provide wide-access to the program, any person currently practicing IONM is eligible to apply and CANM Full Members are given preferential access to individual courses and do not have to apply for the entire program. Non-practicing applicants must meet minimum entry criteria of Bachelor's degree in health-related science with courses in anatomy and physiology.

Feedback on the proposed changes has provided valuable insight to help guide the process. Everyone who has participated has played an essential role in making this initiative one that the entire Canadian IONM community can stand behind. In the coming months, a finalized pathway to obtain the CINP designation will be unveiled to the CANM membership and FULL members of the association will be tasked with voting on the finalized proposal. Stay tuned.

Intraoperative Neurophysiological Monitoring Graduate Certificate Program

The Canadian Association of Neurophysiological Monitoring (CANM) and The Michener Institute of Education at UHN have partnered to introduce a one-of-a-kind Intraoperative Neurophysiological Monitoring (IONM) Graduate Certificate Program.

Full CANM members are permitted to take courses individually and non-sequentially without applying for the Graduate Certificate.

These courses are ideal for IONM practitioners looking for professional development or technologists interested in taking their career to the next level.

	Start date	Register by
IONM 130 Intraoperative Neurophysiological Monitoring Modalities I	April 30, 2018	April 20, 2018
IONM 160 Advanced Topics in Intraoperative Neurophysiological Monitoring	April 30, 2018	April 20, 2018

Register today for **Spring 2018** courses!

For more information and to register visit **MICHENER.CA/CE/IONM**

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CANM CANADIAN ASSOCIATION OF NEUROPHYSIOLOGICAL MONITORING

Those Magnificent Men and Women and their Neuromonitoring Machines

For the past twenty years I have had the pleasure to provide anesthetic care for children undergoing a variety of surgical procedures, both elective and emergent. For the first five years of my practice, intraoperative neurophysiologic monitoring was not available where I was working. We were performing invasive scoliosis surgery without knowing if the spinal cord was being injured as it was straightened. Our neurosurgeons were resecting tumors from the spinal cord or brain without knowing if nerves vital for motor or sensory function were being damaged. Instead, we were using wake-up tests, where the patient would be woken up in the middle of surgery (yes, the middle of surgery!) to determine if he or she was paralyzed or not. Unbelievable, but true.

Today, I could not imagine doing such cases without the use of neuromonitoring. Our expert team of neurophysiologists provide us not only with continuous feedback on the integrity of nerve function in our patients, but also anesthetic depth, and with impressive accuracy. Surgeons and anesthesiologists are keenly aware of the vital role neurophysiologists play in caring for our surgical patients, in keeping them safe and giving us an early warning sign of possible neural injury.

Allow me to share with you a few clinical examples which highlight the awe-inspiring professional relationship between our three sub-specialties.

An adolescent male with significant scoliosis was undergoing posterior spinal instrumentation and blood loss was considerable. The anesthetic team felt they were keeping up with the bleeding however the mean arterial pressure fell below the preoperative baseline for periods of time. The neurophysiologists noted a decrease in signals that seemed to coincide with these drops in blood pressure, and pointed out the trend to the anesthesia team. As a result, inotropic support was started to maintain a normalized mean arterial pressure. SSEP and MEP signals stabilized with this maneuver.

This is a very simple example of the valuable information we can gain from neurophysiologic monitoring, and how it affects anesthetic practice. In fact, we now have a much lower threshold to start inotropic support in these patients, thanks to the added information we gain from neuromonitoring.

An international patient with severe kyphoscoliosis was brought to our institution for corrective spinal surgery. There was a language barrier as well as some developmental delay. After anesthetic induction and application of neuromonitoring, the patient was flipped from supine to prone position. Immediately upon flipping both motor and sensory potentials were abolished at the thoracic level.

These potentials normalized when the patient was turned supine, and again were lost with a second attempt at prone positioning. It was apparent there was instability at the thoracic level that was identified only when neuromonitoring was applied. As a result the surgical approach was altered and the patient underwent successful corrective surgery without neurologic sequelae.

Those Magnificent Men and Women and their Neuromonitoring Machines

An unfortunate young child with a posterior fossa tumor was scheduled to undergo craniotomy and debulking of tumor. As a result of obstructive hydrocephalus his skull was quite thin. Soon after anesthetic induction neuromonitoring was applied and baseline values recorded. A surgical headrest with pins was applied to the frontal and parietal scalp and the patient was turned prone. Surgery proceeded and was uneventful for the first hour when suddenly all signals were lost from one side. The only clinical observation at that point was that blood transfusion requirements seemed greater than expected based on observable bleeding. Our neurophysiologists quickly ruled out a technical cause for this sudden unilateral loss of signals and reiterated their findings to the entire operative team. Because their concern was taken seriously, an emergency head ultrasound was performed which revealed an expanding epidural parietal hematoma.

The patient was immediately flipped to supine, and a craniectomy was performed revealing a very large hematoma. One of the pins in the headrest had fractured the skull which tore a branch of the middle meningeal artery, causing the epidural hematoma. Once the hematoma was evacuated and treated, surgery for tumor resection proceeded and the patient eventually recovered with no long-term neurologic sequelae.

These are just a few of the many examples where neuromonitoring has made a significant difference to a child's life. There is no doubt in my mind the children we take care of in the operating room are safer when neurophysiologists are involved in their care.

Even when they are not saving lives by alerting us of impending but preventable neurologic doom, neurophysiologists influence my anesthetic practice in a positive way on a regular basis. Their ability to accurately estimate anesthetic depth in my patients is uncanny. I now tailor my anesthetic doses to the interpreted EEG recordings provided to me by neurophysiologists, rather than my conception of how much anesthetic the patient should be receiving. They always seem to get it exactly right. This has allowed me to titrate down on my anesthetic to levels that historically I thought would be too low. As a result, once surgery is completed, our patients now wake up in a timelier manner.

My sincere thanks to all you neurophysiologists, for all you do in helping care for patients young and old. I obviously would not wish for any of my own children to have to undergo major brain or spine surgery, but if they did, I would absolutely want you to be there, helping take care of them.

Cengiz Karsli, BSc, MD, FRCPC
Attending Anesthesiologist
Anesthesia Lead, Pediatric Liver Transplant and Trauma
The Hospital for Sick Children
Associate Professor, University of Toronto

Evidence-based practice
and IONM provides fertile ground for debate

Evidence-based principles evaluate the utility of a medical treatment using rigorous scientific approaches. The pinnacle of this endeavor is the randomized control trial (RCT). The essence of a controlled trial is the statistical comparison of a test treatment versus an existing treatment or a placebo treatment. Ideally a RCT testing IONM would evaluate neurologic outcomes of patients randomly assigned to IONM versus those without IONM; or perhaps a sham IONM group (patients set-up for IONM but without feedback to the surgical team). It is clear from this description that there are ethical problems with an IONM RCT study design. Because of this, less rigorous methods of evaluation must be used and over time the balance of evidence is compiled and assessed. So far this situation has done little to settle the issue of evidence-based utility of IONM. I am going to show two recent examples in the literature of how inappropriate IONM data evaluation can potentially lead to the conclusion that IONM is ineffective and a wasteful practice.

In the Journal of Neurosurgery a recent article entitled, ***"Awake" clipping of cerebral aneurysms: report of initial series*** (1) reported a case series where conscious neurological testing was used during temporary or permanent clipping of cerebral aneurysms. The authors justified the use of the awake procedure as it allowed for physical assessment of the patient because "(d) espite detailed neurophysiological monitoring, morbidity and death as a result of these 2 steps are well documented in the literature". The authors used physical examination in conjunction with EEG, SSEP and MEP to provide neurologic assessments in 30 surgical patients. In addition, "All interpretations of the electrophysiological monitoring results were made by a specially trained neurologist in the operating room. " Three patients experienced neurological deterioration during temporary clipping that was in agreement with the neurophysiological testing. However, an additional 3 patients experienced neurologic decline (all motor) without changes in EEG, SSEP or MEP. The authors described this as a "...10%... false negative neurophysiological monitoring ..." rate, justifying their use of an awake procedure with physical examination.

Did MEP testing fail to detect the developing ischemia? Or was there a technical reason for reported outcome? The authors MEP data is poorly displayed and described but we can ascertain that bilateral MEP from abductor pollicis brevis, abductor hallucis and tibialis anterior were successfully recorded. Unfortunately the MEP stimulus details are not given. This is critical as we cannot compare the MEP stimulus settings of the patients where physical examination and MEP data match versus the "false negative" group. We do not even know what stimulus montage was used or whether the authors determined stimulus thresholds.

Why is this important? Let's refer to the seminal work of Rothwell et al. (2) for guidance. What Rothwell and colleagues showed was that transcranial electrical stimulation (TCS) activated the corticospinal tract at discrete locations with increasing stimulus intensities. At near threshold stimulus intensities the axons near the cerebral cortex are activated (ideal for aneurysm IONM) whereas the cerebral peduncles and pyramidal decussation are stimulated with intermediate and high intensities of TCS. We must immediately be suspicious that MEP stimulus intensity used in

Evidence-based practice and IONM provides fertile ground for debate

the J. Neurosurg article (1) may have been high enough to activate distal motor tract axons which by-passed the developing ischemic locus and produced false negative MEP results.

Experienced neuromonitorists know that stimulus intensities for acquiring leg MEPs are usually higher compared to hand MEPs and that stimulus intensity and montage can affect how deeply stimulus current activates the corticospinal tract, particularly using the C3/C4 montage (3). In fact some IONM practitioners recommend the use of the C3 or C4 referenced to Cz for more focal stimulus application (3). Without important MEP details readers cannot assess the validity of the "Awake" author's conclusions. Details are important and without them the most parsimonious explanation for their results is technical failure in MEP monitoring leading to distal motor tract activation and false negative outcomes. The "Awake" paper (1) emphasizes how inappropriately applied or interpreted IONM can lead to erroneous conclusions and misguided assumptions about the value of neuromonitoring.

The second paper I want to highlight is the ambitiously entitled ***"Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord"*** (4). This is a meta-analysis that examined a large body of literature in order to evaluate the diagnostic, therapeutic and cost effectiveness of IONM. The authors divide the studies according to their statistical levels of evidence (I, II, III) and vetted the impact of the studies based on the assigned level of evidence. The authors found that the diagnostic utility of IONM "is a reliable and valid diagnostic adjunct to assess spinal cord integrity" based on numerous level I and II studies. But the real value for IONM is the ability to prevent postoperative neurologic problems. It is in their therapeutic evaluation of IONM that an unfortunate bias surfaces and weakens their position that IONM offers no therapeutic benefit during spine surgeries.

Two level II studies which Hadley et al. (4) rely heavily upon for their therapeutic recommendations for the use of IONM have notable problems which are not mentioned by the authors. The first is the study by Harel *et al.* (5) who retrospectively compared outcomes of patients receiving surgery for intradural extramedullary tumors with IONM versus a historical control group who did not receive IONM. The conclusions from the study were that new cases of neurologic deficits in those patients who received IONM (10%) were not different from those historical control patients who did not receive monitoring (14%). What is not mentioned by Hadley et al. was that 10 of 41 IONM patients (24% not 17% as indicated in Harel et al.) received spinal instrumentation compared to 0% for the historical controls. This is a serious study design flaw and Harel et al. admit that this "... probably poses increased neurological risk" to those patients. Why this detail is not mentioned is unfortunate and dramatically compromises the conclusions of the quoted study (5) and the value assigned to this work by Hadley *et al.*

The other level II study cited in the "Guidelines" was the work by Choi et al. (6) who examined the rate of gross tumor excision and neurologic outcome in 76 patients undergoing surgery for intramedullary spinal cord tumors (IMSCT) with and without IONM (SSEP and muscle MEP). Again pertinent details are omitted by the "Guidelines" authors such as the fact that the IONM group had 76% gross total excision versus 53.4% in the controls ($p = 0.049$, univariate

Evidence-based practice
and IONM provides fertile ground for debate

analysis). Only when multivariate regression analysis was performed to factor in group heterogeneity did statistical significance fail (p = 0.119). But perhaps most importantly, Choi *et al.* did not use D-wave monitoring which has been demonstrated to be a superior method over muscle MEP for monitoring ISMCT cases (7,8).

The Hadley *et al.* paper begs the question: **How can IONM possess diagnostic utility yet lack therapeutic influence?** Clearly it is not a deficit in the technology but lapses in information transfer between neuromonitorists and the surgical team (9) and clear strategies of action in response to an alert. There are no consistent interventional protocols being applied during legitimate IONM alerts and alarm criteria for MEP monitoring remains inconsistent (8). However, the use of interventional checklists has been advocated (10) and represents a rational method to reconcile diagnostic and therapeutic inconsistencies of IONM. Recently it has been shown that IONM alerts followed by appropriate interventions significantly improves neurologic outcomes compared to those patients in whom IONM alerts were not followed by an intervention (11).

My goal in presenting these two articles was to highlight how impressions and bias can be formed with respect to IONM. The first article (1) showed that improperly applied MEP can lead to false negative results that can be devastating for patients and falsely denigrate the use of IONM. The second paper (4) demonstrated that using literature reviews to formulate clinical guidelines can obscure important details that may need to be considered. Moreover, sweeping guidelines such as those proposed (4) should involve multidisciplinary contributions to maximize the necessary synthesis of large volumes of data.

Marshall Wilkinson BSc (Hon.), MSc, PhD
President, CANM
Neurophysiologist
Section of Neurosurgery
Health Sciences Centre
Winnipeg, MB
Canada

CLICK HERE for ***Awake*** article

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