CANADIAN IONM NEWS
Official Newsletter of CANM

Message from the PRESIDENT

Dear neuromonitoring colleagues,

CANM members and interested observers may be aware of some of the challenges currently facing the field of neuromonitoring. A couple issues that come to mind are the needs for training and education in IONM as well as concerns as to who should be interpreting IONM results; these two matters are of course not necessarily mutually exclusive. The historical variability in IONM training and the need to address these inconsistencies has been a recognized concern since the establishment of CANM. The Michener-CANM IONM program is a first step in providing IONM-specific education that is available to a wide variety of interested individuals. We are, of course, aware that this represents only the first step in establishing IONM professional education and training in Canada.

CANM has recently outlined our philosophy for the future direction of IONM training in Canada in a Commentary appearing in The Canadian Journal of Neurological Sciences (1). A public reckoning of our strategy was perhaps overdue as relevant stakeholders may not be aware of our developments and opinions contrary to ours have already been published. Now that our goals are in the public domain differing views will be a normal part of the evolutionary process of our profession. At the moment, IONM in Canada is a virtual clean slate whereby the requirements and standards of practice remain to be formally established. This must be an inclusive process that involves the IONM community and other health care providers. I emphasize that this process is not about infringing on the professional territory of others or carving out revenue generating "schemes" or forcing people to perform above their level of training or experience. This is about providing the best possible training in order to deliver the best possible patient care utilizing the most fiscally prudent delivery model. Regardless of where one stands in the interpretation debate the need for IONM training and education is a necessity that the present IONM community felt compelled to initiate. This need remains true regardless of the academic level of education that is possessed prior to starting IONM training.

Contents

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CANM
CANADIAN ASSOCIATION OF NEUROPHYSIOLOGICAL MONITORING

This process has occupied a great deal of time and energy from some very dedicated IONM practitioners both in and outside of our country. To all those people involved thank you for your contributions.

CANM's goal is to provide a foundation of learning in order to achieve "the expert in the room" philosophy. This means that the IONM interpreter is physically present in the operating room bolstered by clinical situational awareness and the ability to contribute to remedial measures should signal changes occur. Webster's defines an "expert" as:

: having, involving, or displaying special skill or knowledge derived from training or experience...

There are many IONM practitioners who by virtue of their experience can consider themselves "experts". No one at CANM would dispute this. But our vision looks into the future and to the next generation of neuromonitorists. We have started our education initiative and are planning a national accreditation process. This will provide a recognized standard and level of achievement in intraoperative neuromonitoring knowledge that has been objectively demonstrated. People should not feel threatened by this and certainly for current neuromonitorists challenging the proposed national examination remains voluntary.

Achieving an "expert" status should be a life-long professional goal for us all; a goal that one continues to approach but is never fully attained. I continue to learn new things about IONM including delightful nuggets gleaned from the current Michener curriculum. Regardless of one's experience everyone has something new to learn in the field of IONM.

Recently a good friend of mine reminded me that our best plan of action is to "stay the course" as there will always be those that see a different path or remain uncomfortable with change. In navigating this plan we remain open to new ideas and constructive criticism. Above all we look forward to working, learning, and supporting all our colleagues moving forward.

Yours,

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

(1) Wilkinson, M.F., Houlden, D., Morris, S., Holmes, L.M., Strantzas, S. A Strategic view for intraoperative neuromonitoring in Canada 2017. Can. J. Neurol. Sci. 45 (3): 259-261, 2018.

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Editor's Note

The previous issue of Canadian IONM News (Volume 7, Issue 1) featured an article from Marshall Wilkinson entitled Evidence-based practice and IONM provides fertile ground for debate. In this piece, the author drew our attention to two recently published articles in reputable journals. One of those articles, a meta-analysis by Hadley and colleagues entitled Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord[1] has evoked a strong reaction from the IONM community.

In June 2018, a letter to the editor of Neurosurgery from a prestigious group of American Society of Neurophysiological Monitoring (ASNM) members was published[2]. It expressed concerns regarding serious methodological flaws and systematic errors that substantially limit confidence in the recommendations. Furthermore, it requested that the authors issue an erratum to reclassify the paper as a systematic review since it does not meet the critical components of a guideline and for the reason that a biased review causes irreparable harm in the erroneous information presented to surgeons and patients who may benefit from IONM.

The letter can be viewed here:
https://academic.oup.com/neurosurgery/article/82/6/E190/4955828

Hadley et al. issued a reply[3] to the letter, whereby they stand by their publication and its contents.
The reply can be found here: https://academic.oup.com/neurosurgery/article/82/6/E192/4955830

Wilkinson and Houlden[4] also submitted a letter to the editor which has been e-published ahead of print. In this letter, they bring into question the Level II studies that the recommendations were based upon. They go on to suggest that communication and use of interventional checklists may help to synchronize therapeutic benefits of IONM with its diagnostic efficacy.

The letter can be viewed here:
https://academic.oup.com/neurosurgery/advance-article/doi/10.1093/neuros/nyy157/4983181

References:

1. Hadley MN, Shank CD, Rozzelle CJ, Walters BC. Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord. Neurosurg. 2017; 81(5):713-732.

2. Vogel R, Balzer J, Gertsch J, Holdefer RN, Lee GR. Moriera JJ, Wilent B, Shils JL. Letter: Guidelines for the use of electrophysiological monitoring for surgery of thehuman spinal column and spinal cord. Neurosurg. 2017; 82(6):E190-191.

3. Hadley MN, Shank CD, Rozzelle CJ, Walters BC. In Reply: Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord. Neurosurg. 2018; 82(6):E192-193.

4. Wilkinson M, Houlden D. Letter: Guidelines for the use of electrophysiological monitoring for surgery of the human spinal column and spinal cord. Neurosurg. Epub: 24 April 2018

NEW FULL MEMBER

Tara Palmater - Fredericton, NB

2018 CANM Membership Fees

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Raising Mean Arterial Pressure Alone Restores 20% of Intraoperative Neuromonitoring Losses

This article originally appeared in The ASNM Monitor blog on Monday, January 22, 2018.
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Anyone who works in neuromonitoring will tell you that the #1 reason why we lose MEPs or SSEPs during spine surgery is hypo-perfusion of the spinal cord. Indeed, the relationship between spinal cord perfusion and neuromonitoring (IONM) data is intimate: An adequately perfused spinal cord optimizes conduction-based data (i.e., MEP and SSEP), and a hypo-perfused spinal cord can cause loss of data or inability to acquire baseline data. Given that spinal cord perfusion is closely related to the mean arterial pressure (MAP), we always try to ensure that the MAP is maintained within an optimal range.

Every patient has different needs in terms of the mean arterial pressure (MAP) that will maintain adequate spinal cord perfusion, and thus function, and thus IONM signals. During spine surgery, we're always working with anesthesia to maintain the appropriate pressure and we understand that achieving that optimal MAP can be challenging in some patients.

Sometimes the MAP slips too low, and we start to lose our signals. It's a classic progression: MEPs deteriorate first, followed by SSEPs later. That's because MEPs rely on conduction across the synapse between the upper and lower motor neurons. These synapses occur in the spinal cord's ventral gray matter, they have a high metabolic demand, and they're quite sensitive to changes in perfusion. So, the time to electrical failure is very short when blood supply is low. The SSEP pathway doesn't synapse in the spinal cord and the dorsal column white matter tracts have a much lower metabolic demand. So, the time to electrical failure is much longer.

There's an old saying in the world of stroke care: "Time is brain.". The same is true in spine surgery: Time is spinal cord. When spinal cord perfusion falls below the functional threshold, the clock starts ticking as ischemia can ultimately cause an infarct. The penumbra between onset of ischemia and onset of infarct is what we call a critical window of opportunity to perform an intervention, and the first thing we usually do is request an increase in the MAP.

How frequently is this strategy effective? A recent article published in Spine[1] assessed the effect of different interventions in restoring IONM signals in pediatric spine surgery. This was a multi-center prospective study of 452 patients undergoing posterior spinal deformity surgery. The results are exactly what we would expect, increasing MAP is highly effective first line of defense against spinal cord hypo-perfusion.

Of the 30 patients who had a significant IONM signal alterations in this study, 20% had return of signals due to an increase in MAP alone with no other interventions (MAP increased from x = 68 to 86 mmHg). On average, signals returned to baseline after 16 min. In 60% of patients, MAP was raised from x = 72 mmHg to 86 mmHg in conjunction with other interventions and signals returned to baseline after an average of 37 mins. The rest of the patients had signal changes unrelated to MAP. The authors argue that raising MAPs above 85 mmHg should be considered the first step in response to IONM signal changes, as this alone was successful in 20% of patients without sacrificing deformity correction.

A wonderful statistic not overly discussed in this paper was that there were zero bad spinal cord outcomes, meaning that performing some form of an intervention in each of the 30 alerts returned data to baseline, which was a strong predictor for success. All patients had return of signals at the conclusion of the procedure with one patient having postoperative neurological sequelae.

The rationale for having an adequate MAP extends well beyond making the neuromonitoring team happy. Increasing MAP in response to an IONM data change is universally used in spine surgery, and therefore serves as a common therapeutic intervention. However, we must never (ever) forget that an appropriate MAP during times of risk to the spinal cord is also prophylactic and makes the spinal cord more resilient to any iatrogenic or peri-surgical insult.

Interestingly, many of the alerts in this study occurred during pedicle screw placement, and not just during the correction. This suggests that MAP should be maintained at 85 mmHg during all times of risk, including screw/hook/sublaminar wire placement, osteotomies, etc. This can also include surgical exposure in certain populations like marked kyphoscoliosis patients who are at risk from positioning alone. Given that increased MAP is both therapeutic and prophylactic, maintaining MAP at 85 mmHg is likely a good idea in any cervical or thoracic spine surgery, regardless of diagnosis.

A final thought, increasing MAP doesn't always equate to increasing spinal cord perfusion. Pure vasoconstrictors, like phenylephrine, increase MAP but their failure to increase cardiac output may do little to benefit spinal cord perfusion. In situations where hypo-perfusion is suspected, a better approach may be to consider epinephrine which increases heart rate, vascular resistance and cardiac contractility. The result of increasing the cardiac output is more blood flow to regions at risk for ischemic injury.

Adam Doan, DC, D.ABNM
Rich Vogel, PhD, D.ABNM

References:

[1]Yang J, Skaggs DL, Chan P, Shah SA, Vitale MG, Neiss G, Feinberg N, Andras LM. Raising Mean Arterial Pressure Alone Restores 20% of Intraoperative Neuromonitoring Losses. Spine (Phila Pa 1976). Epub: 2017 Oct 18.

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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.

- Prepare for a career in IONM
- Be certification ready

The online program comprises six courses ranging from basic sciences to advanced topics in IONM.

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2	Basic Principles of IONM	JAN - APR	5	Considerations for IONM	JAN - APR
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CANM thanks Medtronic of Canada for their generous support of this education

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CANM CANADIAN ASSOCIATION OF NEUROPHYSIOLOGICAL MONITORING

Annual General Meeting

Saturday September 15, 2018

16:30 MDT

Hilton Garden Inn Downtown Calgary

We encourage everyone to attend the AGM and hear more about the exciting things that have gone on in CANM over the past year and future directions.

Special Announcement:

Voting results on the proposed Pathway to Certified Intraoperative Neurophysiology Practitioner (CINP) accreditation will be released!

Executive Board Elections will be held during our Annual General Meeting

Candidates nominated for the position of Secretary include: *Aleksandra King*

Candidates nominated for the position of Treasurer include: *Samuel Strantzas*

Candidates nominated for the positions of Director (4 Positions) are: *Jessica Cherwick*, *Laura Holmes*, *Susan Morris*

Full members unable to attend in person are entitled to vote by proxy. Information will be sent via email.

Thank you for your support,
CANM Executive Board

Greetings from Down Under

Thank you to Laura Holmes and the Executive Board of the Canadian Association of Neurophysiological Monitoring for reaching out to our association on IONM in Australia, New Zealand, and the greater Australasian region.

IONM in this region is still a developing industry. Australia and New Zealand have had IONM services available in most major public hospitals with neuroscience departments since its employ with SSEP starting back from the 1980's and the addition of TceMEP monitoring introduced in the mid 1990's- early 2000's, however the availability of IONM outside of any leading public centers has been relatively limited to the last 10 years. Australia alone within the last decade has seen an increase in the presence of in-house neurophysiologists and neurologists now working in most major hospitals. Many hospitals within the public and private sectors across Australia and New Zealand and Singapore now use neurophysiology technologists that are contracted independently or are sourced from one of the two chief private companies offering IONM in the Australasian region. Other countries within the region have similar models however services are limited again to the major centers.

As IONM is still a relatively new field within Australia, New Zealand, and the greater Australasian region, there is a lack of financial support for the provision of IONM and a lack of experienced neurologists and neurophysiologists outside of any leading hospitals. Because of this, the model typically employed involves a technologist working independently under the direct supervision of the surgeon. Some anaesthetists also offer IONM services as an addition to their anaesthetic services. Surgeon driven systems have also found their niche within this field.

In 2015, the Australian Association of Intraoperative Monitoring (AAIM) Inc. was formed with the goal of improving the profile of IONM in Australia, New Zealand, and the Asia Pacific region. The first AGM was held in 2016 whereby our national executive committee (NEC) was elected and a constitution and program was created. In 2017, a program of educational events was established entitled "AAIM Live" which is offered free to members.

So far we have had two AAIM Live meetings, both a success, held at North Shore Private Hospital in Sydney made possible through the help of prominent spinal surgeon and Medical Advisory Consultant to AAIM, Dr. Brian Hsu. Dr. Hsu would operate and allow us to broadcast the procedure to an education room through the surgical overhead light camera. In addition to this, a live transmission of the IONM screen used by the technologist in theatre was also run alongside the surgical broadcast, allowing those watching to witness the ongoing procedure and how the IONM was applied. The first surgery was an L2-S1 posterior fusion using PTN SSEP, 10 channel EMG, TceMEP and pedicle screw testing. The second surgery was a multi-level anterior cervical decompression and fusion which utilized upper and lower SSEP, TceMEP and EMG. In addition to live broadcasts, presentations were given on IONM, the surgical procedure, and instrumentation.

In March of this year, AAIM held the 1st Annual Scientific Meeting on the scenic Gold Coast. Dr. Aatif Husain and Ms. Emily Kale (CNIM) from Duke University in North Carolina, along with Dr. Francesco Sala from Verona, Italy, and Professor Lo Yew Long from Singapore General Hospital were our keynote speakers. Other speakers included local expert technologists, neurophysiologists, and physicians. It was a well-supported meeting with over 40 attendees and sponsorship from local neurophysiology companies.

Education in IONM is still developing here in Australia. Currently the standard that most facilities employ for technologists is a base qualification of a bachelor degree in the health sciences with a neurophysiology component. There was a bridging graduate certificate in clinical neurophysiology through Charles Sturt University which many technologists hold, however, unfortunately the course is no longer offered. Sydney University recently created a masters and graduate certificate program in clinical neurophysiology with an IONM component.

There is no current credentialing system in the Australasian region, however AAIM is currently developing practical education facilities and moving towards a certification/accreditation process. Accreditation will be measured using a system similar to ABRET's CNIM but will also include a practical viva assessment. The practical viva component is an important addition to assess the practical skills of applying technologists due to their independence in theatre.

The future of IONM provision in Australia, New Zealand, and the Asia Pacific looks bright. Our focus on the future is to train neurophysiology technologists in the skills to competently provide IONM services independently for surgeons; education for surgeons on the usefulness and interpretation of IONM data; and to lobby for proper funding of IONM services.

I hope this gives you all little insight into IONM Down Under. It has been a pleasure writing this article for your newsletter. Please view our website www.aaimonline.com for updated information and upcoming events.
Kind regards,

Anthony Kyte
President – Australasian Association of Intraoperative Monitoring (AAIM) Inc.

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

Gina Bastaldo

University Health Network, Toronto, ON

Gina was a guest speaker at the Operating Room Nurses of Greater Toronto (ORNGT) education session entitled "Looking Ahead in Perioperative Services" on April 3, 2018.

Naureen Bhamani

Alberta Children's Hospital, Calgary, AB

Congratulations to Naureen who recently passed the Certification in Neurophysiologic Intraoperative Monitoring (CNIM) examination.

Peter Heyboer

Trillium Health Partners, Mississauga, ON

Peter is helping with the separation of the EEG and IONM services into individual groups at his institution. The proposal to separate will help with resource availability and scheduling.

CANM Education Commitee

Under the skilled leadership of Susan Morris, CANM has negotiated a new 3-year contract with The Michener Institute for continued offering of the Graduate Certificate in IONM program.

David Houlden & Marshall Wilkinson

The Ottawa Hospital, Ottawa, ON and Health Sciences Centre, Winnipeg, MB

Marshall and Dave's letter to the editor of Neurosurgery regarding the recently published article Guidelines for the Use of Electrophysiological Monitoring for Surgery of the Human Spinal Column and Spinal Cord by Hadley et al. was published April 24, 2018.

https://doi.org/10.1093/neuros/nyy157

Samuel Strantzas

SickKids, Toronto, ON

Sam has provided an opportunity for multiple students enrolled in the Michener Institute Graduate Certificate in IONM program who are located in the Greater Toronto Area to observe a surgical procedure and see how IONM is performed.

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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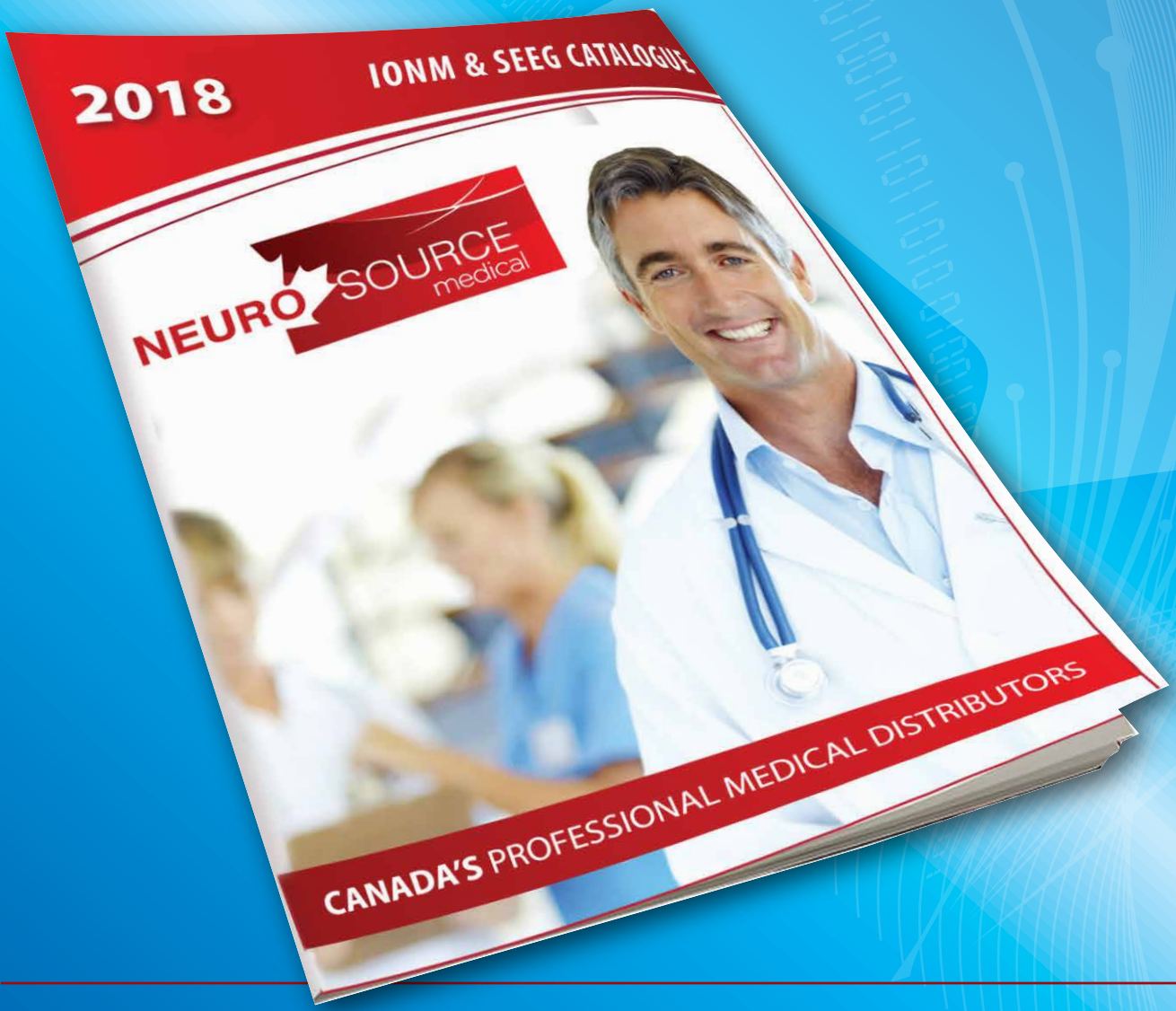

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Why Stimulate Once When You Can Stimulate Twice:

The Utility of Doublets

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

The concept of using double pulses or doublets in neurophysiology is invaluable. This article was written to showcase the utility of doublets for distinguishing purely motor versus reflex responses during nerve root and spinal cord mapping. It is my goal to encourage more clinical studies that can validate its use during routine intraoperative mapping.

Rationale behind doublets

One of my first experiences with doublets came from experiments on transcutaneous spinal stimulation. Working in the lab, I was involved in stimulating spinal nerve roots and/or spinal cord using surface stimulation over the thoracolumbar spine (Fig. 1). We then recorded evoked potentials in the lower extremity which we called root evoked potential (REP). While these REPs were fairly easy to elicit (50-100 mA; 1-ms pulse), the nature of the response (i.e. motor vs. reflex) was more difficult to ascertain. One way to distinguish the two was to examine the latency of the REP. If the latency was short, then the REP would be most consistent with a direct motor response; while if it was long, then it would also include a portion of the reflex loop (see circuit diagram in Fig. 2). Remember that a direct motor response would only involve the motor axon, neuromuscular junction and muscle. While a reflex would also be mediated by part of the primary muscle afferent (Ia) in the dorsal root, synaptic connection with the alpha motoneuron and the most proximal end of the alpha motoneuron, which would all be rostral to the stimulating electrode. The difference in latency is however small when stimulating near the conus medullaris, but the difference becomes more prominent when stimulating near the sacrum (compare sites 'A' and 'B' in Fig. 2; see Maertens de Noordhout *et al.* 1988). It goes without saying that the separation between both motor and reflex components is much more substantial (i.e. 5 ms for motor vs. 30 ms for reflex) when recording motor (M) wave and Hoffman (H) waves in the medial gastrocnemius following stimulation of the tibial nerve in the popliteal fossa.

One approach that is even better suited for this distinction during intraoperative mapping is to use doublets. This involves stimulating the same pathways twice, in close succession, and comparing the size of the second response as a percentage of the first. Generally, direct motor responses do not change during paired stimulation, yet many monosynaptic reflexes, such as the H-reflex, are strongly inhibited. This period of inhibition is well-known in electrophysiology as homosynaptic or post-activation depression (PAD) and can take a few hundred milliseconds or longer to recover. This marked predictable inhibition allows a neurophysiologist the opportunity to re-examine the excitability of a pathway and tease out the origin of an elusive reflex response, as was done with the REP during our transcutaneous spinal stimulation experiments (Roy *et al.* 2012, 2014). For other

[1]*In electrophysiology, we are fortunate to have other complementary techniques that can identify motor vs. reflex pathways that are not entrenched in latency. This can be achieved by applying mechanical vibrations to the homonymous muscle tendon thereby dampening transmission along the primary afferent reflex pathway. Alternatively, voluntarily contracting a target muscle increases the excitability of the motoneuron pool thereby altering the amplitude and threshold of the reflex (i.e. up and down, respectively), but without substantially affecting the amplitude of the M-wave.*

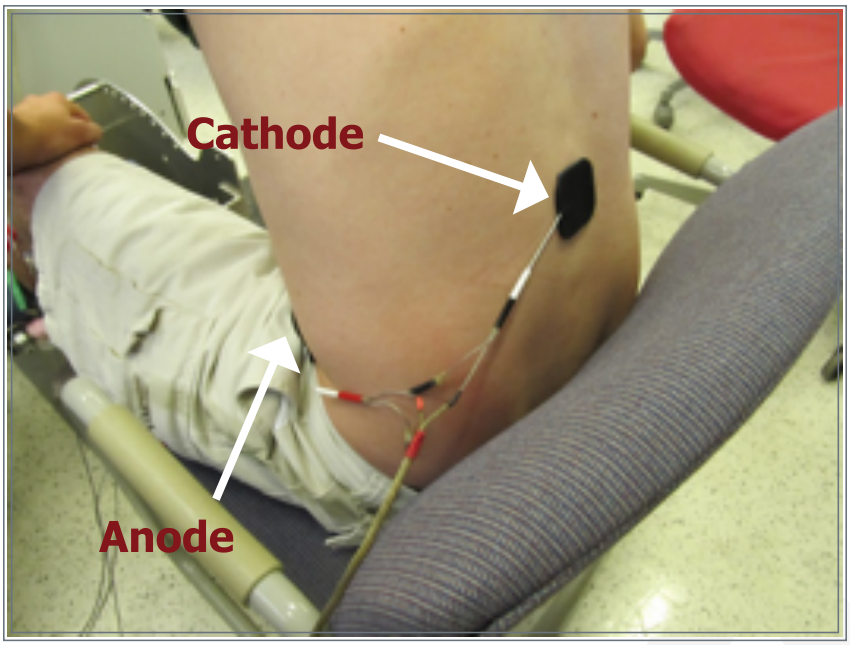

Figure 1. *Experimental set-up showing non-invasive transcutaneous spinal stimulation over the thoracolumbar spinal. The volunteer was seated with the left leg in a metal brace. The cathode was placed midline over the thoracolumbar spine and the anode was placed over the left iliac crest. REPs were recorded in the quadriceps, hamstrings, tibialis anterior, and soleus.*

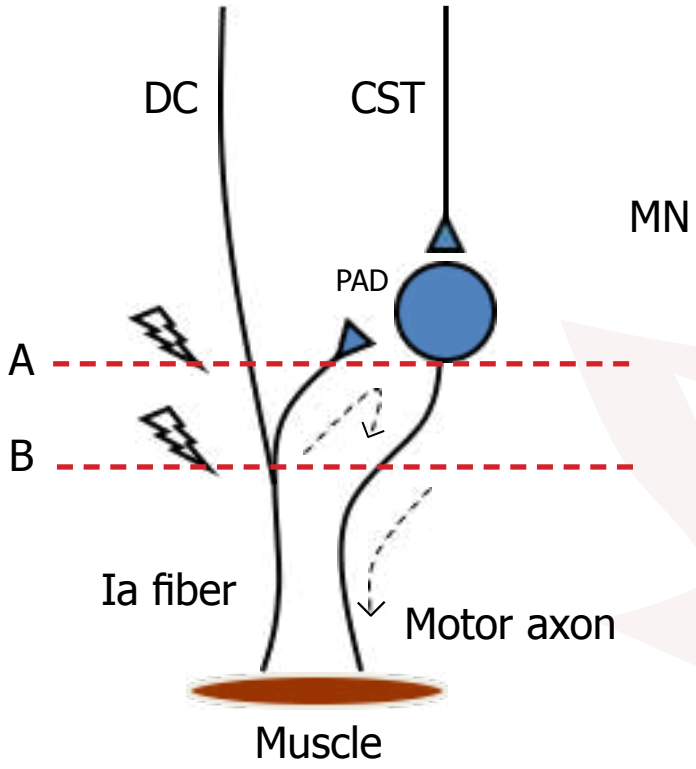

Figure 2. *Circuit diagram of the REP showing the effect of applying electrical stimulation at two different levels ('A' and 'B') along the neural axis. An REP can either be a reflex or a direct motor response (or a combination of both) depending on the stimulus parameters and intensity (not discussed here). The difference in the latency of the reflex vs. motor components is small (i.e. 1 ms) if the stimulation is provided near the dorsal root entry zone ('level A'), but the difference is more substantial if the stimulus is applied further down the spine (level 'B'). The phenomenon of post-activation depression (PAD) only inhibits the reflex pathway as the neuronal inputs reach the motoneuron (MN). PAD will strongly suppress a second reflex elicited within 100 ms of the first.*

Time-course of post-activation depression (PAD)

The recovery of an H-reflex or an REP from PAD can vary based on conditions. Though, generally speaking, the suppression is very strong (almost 100%) when using inter-stimulus intervals < 70 ms (Fig. 3) and the response substantially recovers within the next 200-1000 ms. We and others have shown that PAD of monosynaptic reflexes occurs in many lower extremity muscles (Minassian *et al.* 2007; Roy *et al.* 2012, 2014) and the inhibition is preserved under general anesthesia (see Fig. 4; Andrews et al. 2016). The recovery is indeed faster in patients with spasticity (Grey *et al.* 2008) owing to their heightened spinal excitability, as also seen during selective dorsal rhizotomy procedures in patients with spastic cerebral palsy (see Park *et al.* 2006).

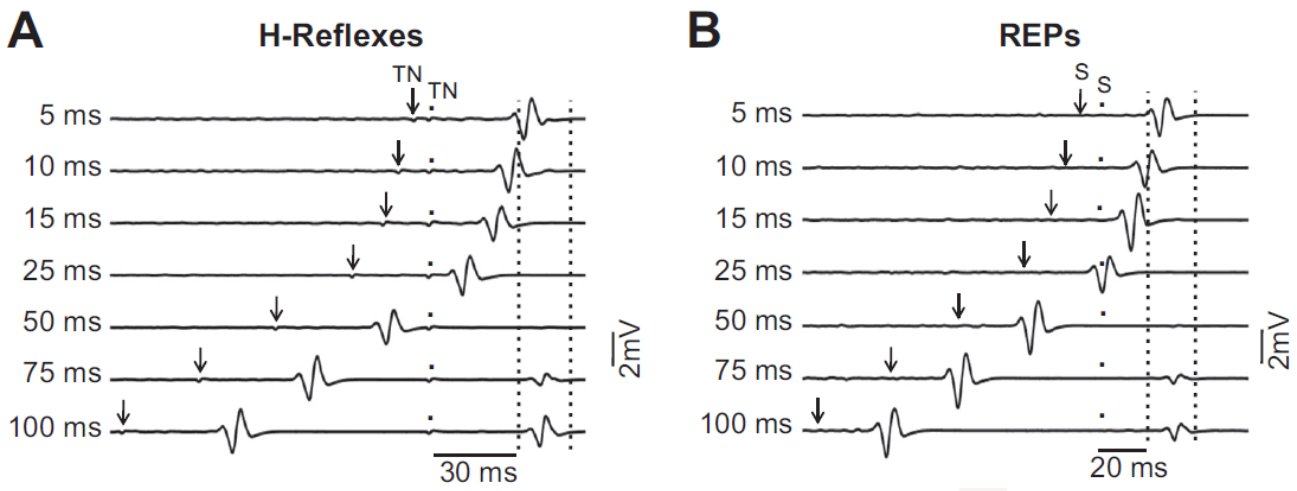

Figure 3. *Recovery of the H-reflex and REP from PAD. Recordings are from the soleus muscle following non-invasive transcutaneous stimulation over the tibial nerve (label 'TN' in A) in the popliteal fossa and lumbar spine (label 'S' in B). The second reflex was expected within the two dotted lines. The inter-pulse interval is shown on the left. The recovery from PAD was qualitatively similar with both approaches; except that the suppression of the REP was stronger (i.e. the recovery was slower). Figure from Andrews et al. 2015.*

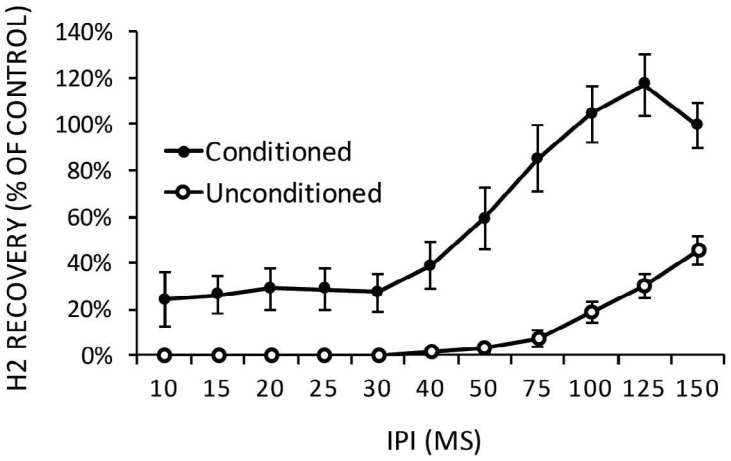

Figure 4. *Time-course of PAD of the H-reflex in the medial gastrocnemius during general anesthesia. Data are from 20 pediatric patients undergoing spinal deformity correction surgery. Eighteen patients were tested during a total intravenous anesthesia and 2 were tested with the addition of 0.2-0.5 MAC of sevoflurane. A value of 100% represents full recovery. The inter-pulse interval (IPI) represents the delays between the two successive pulses shown in milliseconds. Figure modified from Andrews et al. 2016.*

Mapping dorsal column (DC) and corticospinal tract (CST) fibers

Deletis and colleagues (2018) are the first to demonstrate the utility of double trains when applied over the exposed spinal cord to map dorsal column (DC) and corticospinal tract (CST) fibers. Because both DC and CST stimulation can produce a compound muscle action potential (CMAP), the presence vs. absence of a muscle response as a singular criterion for identifying CST fibers can be problematic (discussed in Deletis *et al.* 2017). This is because direct stimulation to the DC can result in an "H-reflex like" response due to antidromic conduction along DC fibers and the synaptic activation of the alpha-motoneuron via collateral connections (see Fig. 5).

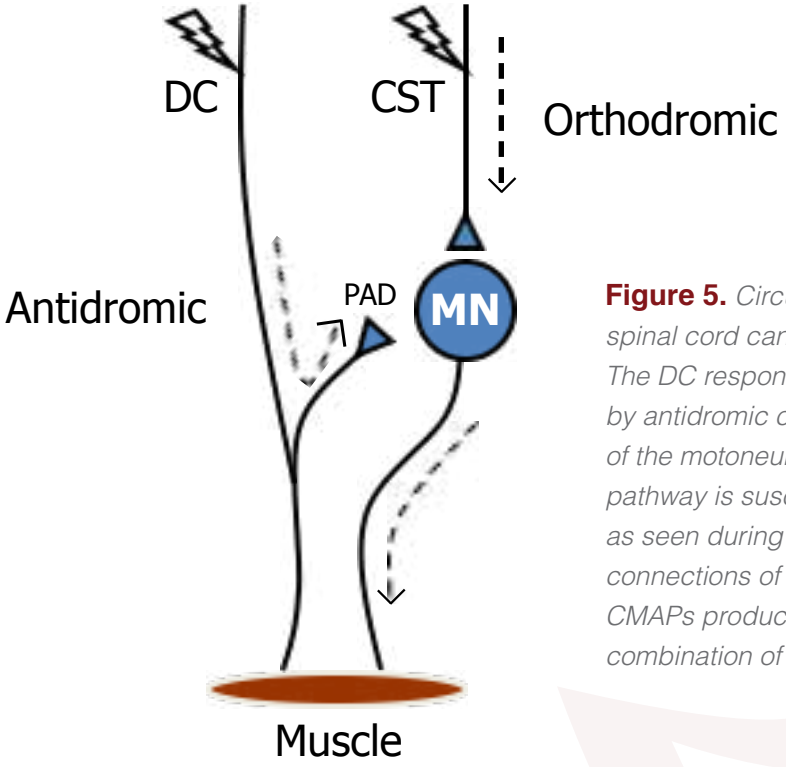

Figure 5. *Circuit diagram showing how direct stimulation of the spinal cord can produce a CMAP from either DC or CST fibers. The DC response is an "H-reflex like" response produced by antidromic conduction along DC fibers and the activation of the motoneuron (MN) via its collateral connections. This pathway is susceptive to strong inhibition, including from PAD, as seen during double train stimulation. While monosynaptic connections of CST and DC fibers onto MNs exist, part of the CMAPs produced by CST and DC pathways may also involve a combination of spinal interneurons (not shown).*

The novel approach introduced by Deletis and colleagues (2018) consists of applying doublet trains 60 ms apart and identifying the presence/absence of PAD (or some form of synaptic modulation) within the reflex pathway as a marker of DC activation (see Fig. 5). The reason why this distinction is possible is that corticomotoneuronal connections, in contrast, do not exhibit PAD nor changes in presynaptic inhibition (not discussed here; Jackson *et al.* 2006). Instead, the glutamatergic pathways from the CST are designed in such a way that they are generally more facilitatory rather than inhibitory. This can easily be seen during routine intraoperative neurophysiological monitoring (IONM) as part of the mechanism responsible for producing double train facilitation. The lack of substantial inhibition and/or changes in morphology therefore provides a convenient guide for identifying CST fibers. Indeed, Deletis et al. (2018) found that mapping the CST fibres using double trains 60 ms apart produced two identical responses in all 11 patients. Keep in mind that a 60 ms inter-train interval falls outside the windows of the early (< 30 ms) and later (> 90 ms) phases of double train facilitation.

When the DC was stimulated using double trains, PAD resulted in the total loss of the second response in the 6 non-spastic patients (55% of sample). The results were however different in the 5 patients with spasticity (45% of sample). This finding was not fully unexpected owing the diminished PAD, and hence heightened spinal excitability in this patient population. In the patients with spasticity, Deletis *et al.* (2018) found that the second reflex was recordable but was always different from the first, being either larger or smaller, and therefore consistent with DC activation. Given the known recovery curve the H-reflex and REP from PAD, it is likely that the inhibition would be stronger at shorter inter-train intervals; however this remains to be examined in these patients during surgery. While larger case series are needed to validate this method, I am optimistic that the approach will prevail given that the dichotomy of responses is strongly supported by a robust neurophysiological mechanism, namely PAD.

Mapping nerve roots in the cauda equina

One extension of this approach, which remains to be fully described in the literature, is to use doublets when mapping dorsal and ventral roots in the cauda equina. Strong suppression of a monosynaptic reflex elicited within 50 ms of the first stimulus would be a strong indicator that a surgeon is stimulating a dorsal root. This data could strongly complement the traditional threshold techniques, whereby CMAPs are much easier to elicit via ventral vs. dorsal roots. I would certainly encourage IONM groups to examine and validate this approach. Software limitations have unfortunately hampered our abilities to capitalize on this neurophysiological phenomenon, but our preliminary tests using a 30-40 ms interval have shown that these doublets are a useful complement to the threshold technique.

Concluding remarks

There are certainly many applications for using doublets during routine IONM. Doublets can be used to confirm whether an evoked potential is real vs. artefactual, for instance. This could be done by testing for refractoriness at short intervals (< 3 ms) or testing for supernormality at 8-10 ms when studying D-waves (Bartley *et al.* 2002) or nerve action potentials. Similar principles have been applied during corticobulbar MEP monitoring of the facial nerve, which have unfortunately demonstrated that this modality is not foolproof (see Tellez *et al.* 2016; Urriza *et al.* 2016). With the ever increasing armamentarium of tests performed during multi-modality mapping, it remains our responsibility to minimize the incidence of false-positive and false-negative results. Understanding the neurophysiology that supports intraoperative neurophysiological monitoring is essential. Likewise, the capacity to modulate waveforms using doublets or double trains is an easy way to gather more information to help refine the quality of our real-time interpretations.

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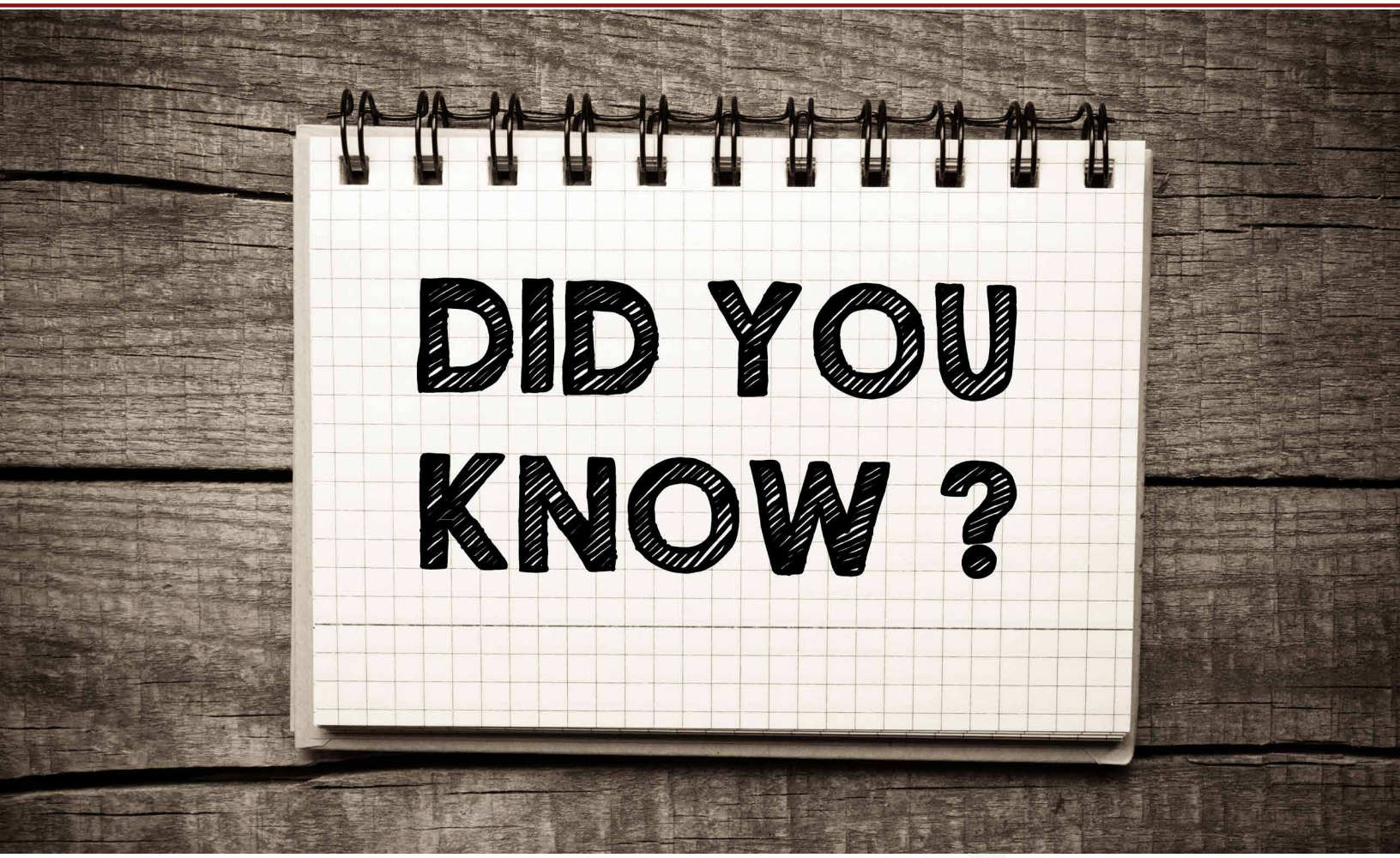

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Interview with IONM Advocate

Michael West, MD, BSc (Med), PhD, FRCSC
Professor of Neurosurgery
University of Manitoba and Winnipeg Regional Health Authority

Dr. Michael West is a neurosurgeon at Health Sciences Centre (HSC) in Winnipeg, MB. He spent several years working in the United States before returning to Winnipeg and establishing Canada's first Stereotactic Radiosurgery Program using Gamma Knife, of which he is now Co-Director. More recently, he partnered with CancerCare Manitoba in the development of a Stereotactic Body Radiation Therapy Program to treat extracranial tumors. He is an Associate Dean at the Max Rady College of Medicine, a professor of Neurosurgery, and has served in many capacities for the Royal College of Physicians and Surgeons of Canada. He has won many teaching awards and authored or co-authored countless scientific publications. Dr. West was instrumental in implementing the IONM program at HSC Winnipeg and continues to be a strong advocate for its use.

Interview conducted by Kristine Pederson.

KP: As a member of the IONM team at HSC, I had the pleasure of conducting an interview with Dr. West. He offered the following information regarding his personal experience using IONM.

MW: I use intraoperative neurophysiological monitoring (IONM) in several procedures. One important example would be during the surgery for cerebral aneurysms. IONM is important in determining the depth of anesthesia during these cases and monitoring the progress of induction of EEG burst suppression which has been shown to protect the brain from ischemic injury and the effects of intracranial hypertension. IONM has often provided us with important information about the length of time that the brain is tolerating temporary clip occlusion of the arterial system during aneurysm surgery. Your feedback has often indicated to us that the period of temporary ischemia has caused unacceptable monitoring changes, leading us to quickly restore circulation to the brain. Also, during the closing phase of neurosurgery a reported asymmetry in the recovery of EEG signals has led us to re-explore the aneurysm repair site. There are several examples of cases in which this scenario led to the finding of unsuspected partial occlusion of a cerebral artery allowing immediate correction of the situation and thereby prevention of a stroke.

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Another example of a strong indication for use of monitoring is the posterior fossa surgical cases, including intrinsic brainstem tumors as well as extrinsic tumors such as acoustic neuromas. Our use of monitoring allows us to be more aggressive with our dissection and excision of tumors in these locations. As long as monitoring is stable, we are confident to continue with dissection of the particular lesion, when we might otherwise be unaware of what is happening to the surrounding neural tissues. My spine colleagues have enthusiastically adopted IONM recognizing its benefits in high risk spinal procedures such as excision of spine tumors, correction of deformities, and fixation of unstable spine injuries, to name some.

KP: As a neurosurgeon who utilizes neuromonitoring in complex surgical procedures, do you routinely make it a part of your practice to inform your patients that IONM will be performed during their surgery? What are the possible benefits and potential challenges of providing your patients with this information prior to their surgery?

MW: I routinely make it a part of my practice to inform patients about the monitoring that will be performed during the surgery. Inevitably, and very much without exception, patients are most likely to be impressed by the level of attention that their case has deserved by the use of such monitoring. They have a preconceived understanding that neurosurgery is highly dependent upon refined technology for good results. They understand very quickly after my discussion with them that the monitoring we propose has very little risk and confers the many benefits that I have outlined above.

I have not had the experience of describing the use of IONM to a patient who has expressed serious reservations about it.

KP: Do you think we will see a time when IONM will achieve evidence-based status given that randomized trials are not likely forthcoming?

MW: I don't think that IONM will achieve evidence-based status based on randomized trials (RCTs), since the surgeons who use it will not be willing to subject this procedure to controlled randomized trials. Having witnessed the benefits of IONM, they are most unlikely to need an RCT to prove its utility. I do believe, however, that the surgeons who have the most extensive experience with IONM have been including a description of its importance in their academic presentations more and more over the years, so that it has become close to a standard of care, if not the standard of care.

Interview with IONM Advocate

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KP: Neurosurgery training (residency, fellowships) are often big influences in determining whether surgeons embrace IONM use. Can you think of any ways in which neurosurgical practitioners can obtain increased exposure to the use of IONM in their practice?

MW: For neurosurgeons who have not had this training during their residency years, it might be fruitful to have a sponsored continuing education session at one of the national Neurosurgery meetings on the use of IONM. This could include surgery vignettes with simulations during which the neurosurgeon who is using monitoring during dissection of an aneurysm, posterior fossa tumor, spinal cord tumor, or a microvascular decompression can experience how efficiently the monitoring devices can be placed, and the changes that occur during surgery, such as varying depths of anesthesia, unintended surgical errors, or unwise manipulations. This could be supplemented by having a "montage" of invited videos recording critical incidents observed at surgery, accompanied by changes in IONM.

KP: Ideally, the field of IONM should be an independently regulated profession. But given the small numbers of IONM providers (especially in Canada) what recommendations would you suggest to achieve this goal? Do you think that an independently regulated status is even necessary for IONM?

MW: I would suggest that you contact the individuals across the country who are involved with IONM and suggest a meeting at a central location, such as Winnipeg. You might be able to combine this with a scientific meeting outlining updates on IONM and have a discussion with those present about this question. Many medical specialties achieved the goal of special status by "founding" associations of like-minded practitioners who determined the requirements for entry into the group and maintenance of membership in the group. You may not aim for independently regulated status, but rather an "association" or "working group".

KP: Are there any lessons that the field of IONM can learn from the development of the Physician Assistant program?

MW: Assistant (PA) program is quite different, because there are more practitioners and the advantages of PAs in practice are evident to physicians at both the primary care and specialty levels. A similarity, however, is the fact that this group was not present in Canada until relatively recently. Physician Assistants did not have an evidence-based argument for their role. It became evident to those who worked with these individuals that there are so many advantages and very few disadvantages to their professional involvement in patient care. The IONM situation is different in that you can point to the strong potential for reducing medicolegal litigation by having input from surgeons who can vouch for IONM and its effects on preventing devastating complications.

Interview with IONM Advocate

Michael West, MD, BSc (Med), PhD, FRCSC
Professor & Head of Neurosurgery
University of Manitoba and Winnipeg Regional Health Authority

KP: One of the arguments against IONM use in low risk procedures is that it unnecessarily increases OR time and cost to procedures. Is this reasonable criticism?

MW: My observations are that you, as a group of specialists in IONM, add very little time to the set up of a patient who requires this monitoring during surgery. In no way do I perceive this as a disadvantage or a reasonable criticism.

KP: You were involved in the establishment of the IONM department at HSC Winnipeg. What challenges did you face and what advice do you have for other Canadian health care institutions who are struggling to introduce an IONM program into their hospital?

MW: At the time that Dr. Kaufmann and I established the IONM program at HSC, there was no such monitoring during any type of surgery in Winnipeg. It was evident to both of us, from our experience in the United States, that such monitoring was mandatory in procedures such as posterior fossa operations for tumors, craniotomies for aneurysms, complex spine surgery, microvascular decompression procedures, and other operations. We made a strong argument to the Winnipeg Regional Health Authority about the benefits of such monitoring and started off with very basic equipment. As more of our surgeon colleagues began to recognize the importance of this technique there became more of a demand for the procedure. The evolution that occurred, as you can see, was the recruitment of highly skilled individuals, under the tutelage of Drs. Marshall Wilkinson and Anthony Kaufmann. As neurosurgeons observed the utility of these techniques, the demand for them became increasingly strong. I would say that presently, neurosurgeons and orthopedic spine surgeons will not perform many select high risk surgeries on the brain or spinal cord without the use of this monitoring. In fact, they will delay these cases until IONM is available, unless the integrity of the patient's brain or spinal cord is severely threatened and immediate intervention is necessary.

Thinking about having to perform some of the neurosurgical procedures discussed earlier without IONM leads me to think of the comparison of doing complex heart surgery without electrophysiological monitoring of cardiac function. No one would consider this. The benefits are so self-evident, and the risks are so rare, that it seems common sense.

Some individuals cite cost as a concerning factor. In the big picture, I do not believe that this is a good argument. The medical-legal costs that are saved by preventing untoward outcomes from brain and spine surgery (by reducing morbidity) are far greater than any expense of IONM.

Intraoperative Neurophysiological Monitoring Graduate Certificate Program

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Regulation of IONM

Laura M. Holmes, MSc, CNIM

The landscape of IONM in Canada is rapidly changing and will continue to change over the years to come as more educational and credentialing initiatives are launched. Throughout ongoing discussions with the Canadian IONM community regarding the proposed pathway to Certified Intraoperative Neurophysiology Practitioner (CINP) designation, the issue of regulation has continually been raised.

Regulation is a complex issue that has a tendency to be misunderstood or misinterpreted in the context of IONM. To properly frame the discussion, it is important to recognize the distinction between regulated and unregulated professions and to understand how they function within the Canadian healthcare system. With this knowledge, we can better understand where IONM is positioned and future avenues to explore.

Regulated Health Professions

- Governed by legislation (regulatory acts and regulations)
- Exclusive right to practise
- Protected professional title
- Mandatory certification, licence, or registration is required
- Mandatory membership in health regulatory college
- Regulation is means to protect public

Examples of Regulated Health Professions

Medicine
Nursing
Dentistry

Health Regulatory College

- Regulates professions in the public interest under a legislative framework
- Government appointed
- Provides right to practise and protected titles
- Responsible for ensuring that services are provided to the public in a safe, professional, and ethical manner
- Responsible for setting standards of practice for the profession, investigating complaints about members of the profession, and, where appropriate, discipline of members

Non-Regulated Health Professions

- No legal requirement or restriction on practise
- Voluntary certification, licensure, or registration may exist

Examples of Non-Regulated Health Professions

EEG techs (except AB, QC)
Clinical Perfusionists
Paramedics
Physician's Assistants
Personal Support Workers

Health Professional Body

- Self-governing association, society, or board
- Voluntary membership
- May offer guidelines for standards and scope of practice
- May offer voluntary certification, credentialing, or registration

In Canada, provincial and territorial governments are primarily responsible for delivery of health care and health insurance, and for the regulation of health professionals. As such, each province or territory has legislation outlining which health professions are regulated and governed by regulatory colleges. From time to time, provinces and territories conduct reviews of this legislation and may decide to regulate additional professions and/or de-regulate professions.

Government-appointed health regulatory colleges or licensing boards operate under a legislative framework and are tasked with ensuring that the public receives safe and ethical care. These colleges and boards are government-regulated and administrated with funding from the provincial or territorial authority.

! Only Regulated Health Professions

REQUIRE a licence to practise !

Select regulated health professions are granted powers to self-regulate. These well-established professions have been delegated the responsibility for setting and enforcing the rules of the occupation while still being governed by legislation. Their regulatory colleges or licensing boards are responsible not only to the public, but also to the members of the profession they are charged with regulating. Nursing is one such example.

Many non-regulated health professions are self-governing. The lack of binding legislation means that no restrictions are placed on practise, and if certification, credentialing, or registration does exist, it is entirely voluntary. These professional bodies usually operate to represent the interest of their members and to advance the occupation, and they may set voluntary guidelines or accreditation options in an effort to promote safe and high-quality professional practice. Some offer a public registry of individuals who have achieved the desired standard (ie. credential, certification).

How are Non-Regulated Health Care Providers (NRHCP) Authorized to Provide Care?

NRHCPs do not have a legislated scope of practice, and, as such, are not directly authorized to perform controlled acts. However, there are provisions in health profession regulations that allow for delegation of controlled acts. Delegation is the process of transferring the authority to perform a controlled act to another person. Both regulated and non-regulated care providers require an order (ie. medical directive) from a professional who is permitted to order (eg. a physician) to perform controlled acts. The legislative provision for delegation arises from the recognition that it is sometimes in the best interest of the patient for someone who is not authorized to perform a specific act to do so.

Non-controlled acts do not require authority to perform and therefore NRHCPs can conduct these duties freely, as they are considered to be in the public domain.

What does this mean for IONM?

Most IONM professionals, like Physician Assistants and Clinical Perfusionists, are unregulated but generally permitted to perform patient care duties within the hospital environment under the supervision and/or direction of a physician. For example: Performing a procedure below the dermis is a controlled act. Therefore, insertion of subdermal needle electrodes for neuromonitoring is a controlled act but under legislative requirements the surgeon is delegating this act to the IONM professional. Under these provisions, an IONM professional is authorized to provide patient care as a NRHCP.

Where is IONM regulated in Canada?

Alberta (AB): The Alberta College of Medical and Diagnostic & Therapeutic Technologists (ACMDTT) regulates Electroneurophysiology Technologists (ENP). IONM is an enhanced practice authorization that ENPs may apply for once they have completed advanced training that has been approved by the College's Council. **For more information**: **www.acmdtt.com**

Quebec (QC): Ordre des Technologues en Imagerie Medicale, en Radio-Oncologie, et en Electrophysiologie Medicale du Quebec regulates ENPs. The legislation is specific to electrophysiological diagnostic technologists and does not make a distinction for IONM. **For more information: www.otimroepmq.ca**

Consultation with provincial regulatory bodies was conducted throughout the development stages of the CINP proposal. By engaging these stakeholders early in the process, we were able to work together to develop a proposed educational preparation and accreditation process pathway for entry to practice that is specific to IONM. Once this proposal is finalized, it will undergo a period of review by the regulatory college and a decision whether to adopt will be made.

That said, the existing regulatory and licensing bodies in AB and QC will continue to have jurisdiction over how IONM is performed and by whom, by virtue of legislation in those provinces.

Does IONM need to be a Regulated Health Profession?

To help answer this question, the Executive Board of CANM engaged the expertise of Monica Testa-Zanin in 2017. Ms. Testa-Zanin is a public policy and lobbying consultant with expertise in allied health professions and regulatory issues. She has prior experience working for the Health Professions Regulatory Advisory Council (HPRAC) which was tasked by the Ontario government in the early 2000s to assess a variety of health professions for regulatory fit. HPRAC provided recommendations to the government which then undertook steps to amend legislation to regulate additional professions and set up regulatory colleges. Kinesiology and Naturopathy are two of the professions that became regulated at that time. Since then, no further professions have been regulated and in fact, steps have been taken to reduce the number of regulatory colleges in Ontario.

It is the opinion of Ms. Testa-Zanin that given tough fiscal decisions in healthcare there is no appetite for creating new stand-alone regulated health professions which substantially add to the financial burden. As a result, governments are now moving away from the traditional legislative regulation and are seeking alternative avenues to ensure the public is protected. Professional registries are one method being employed to ensure public safety without the need to create a new regulated profession with associated licensing college. The province of Ontario has a public registry of Personal Support Workers (PSW). To qualify to be listed on the Registry, PSWs have to meet a certain entrance to practice standard, meet specific ethics and code of conduct criteria, and the Registry has measures of recourse if PSWs violate certain professional standards. Potential clients or employers are able to check the Registry to see if the PSW is listed and is in good standing. This professional registry was Ontario's solution for elevating the standards of a profession that historically had no checks or balances on their level of knowledge, ability, or conduct, and provided a method to protect patient safety.

Ms. Testa-Zanin believes that given the current day political landscape, a proposal to government to create a Registry of IONM Providers seems much more probable than a successful bid to make IONM a Regulated Health Profession. However, given that IONM professionals will always work in a controlled setting (eg. Hospital) under the supervision of an ordering physician there will be even less of an

appetite for governmental control and a bid for Registry may also be unsuccessful. It is with this in mind that Ms. Testa-Zanin recommended that CANM do some self-reflection and consider our strategic priorities and how we might accomplish our goal of elevating the standards of the profession and ensuring patient safety without the need for becoming a Regulated Health Profession or having a government-controlled Registry.

With the exception of AB and QC, IONM professionals currently practice as NRHCPs who have no mandatory legal restrictions or requirements for practise. So, if IONM is unlikely to become a Regulated Health Profession elsewhere in Canada how do we, as IONM professionals, strive to become recognized for the health care services we deliver?

One solution is voluntary certification, credentialing, or registration. Many non-regulated health professions offer certifications or credentials as a means to demonstrate that the individual has achieved the desired standard. This signals to employers, colleagues, and patients that the individual has sought to meet the voluntary requirements set out by the profession and is committed to practising according to the outlined standard. While not mandatory for practice, these voluntary credentials or certifications often become the 'unofficial requirement' once they have gained recognition. The health professional body offering the credential or certification may also list those with the designation on a registry and set their own minimum practice standards, code of ethics, code of conduct, and disciplinary measures for violations. In many ways this is a self-governing 'regulation' of professional practice.

An available credential in IONM may satisfy the desire of many to 'regulate' the profession and those who practice. While becoming a Regulated Health Profession in every province and territory across Canada seems unlikely, there is the opportunity for our profession to apply voluntary recommended standards, ethics, and conduct restrictions, and provide a measure of professional competency through credentialing.

Obtaining the CINP designation will be VOLUNTARY

(unless required by Regulatory College or employer)

The pathway to Certified Intraoperative Neurophysiology Practitioner (CINP) designation presented to the Canadian IONM community is a collaborative effort to offer a credential in IONM. It represents an opportunity for the Canadian IONM community to come together and, as experts in the field of IONM, determine what the desired standard should be and outline the expectations for the profession. With the goal of high-quality and safe IONM patient care at the forefront, our profession can position itself as champions and through voluntary credentialing and registration show our commitment to the Canadian population as well as to our professional practice.

IONM Accreditation

Accreditation, as defined by the Oxford Dictionary, is; The action or process of officially recognizing someone as having a particular status or being qualified to perform a particular activity. The pathway to Certified Intraoperative Neurophysiology Practitioner (CINP) designation is an accreditation process. By offering a credential in IONM, there will be an objective measure of an individual's qualification and achievement which can be used to indicate their suitability for professional practice.

Since 2008, the Canadian IONM community has been engaged in determining the future directions of the profession in this country. Individual voices were united in the desire to move the profession forward by creating a more formalized entry to practice that included IONM-specific education and training. This formed the basis for our collaboration with The Michener Institute to offer a Graduate Certificate in IONM which launched in 2014. There was also a strong desire for the "expert in the room" IONM model of care in Canada, meaning that the IONM interpreter is physically present in the operating room bolstered by clinical situational awareness and the ability to contribute to remedial measures should signal changes occur. To support this philosophy, our community recognized that a strong foundation of learning and skill acquisition would be required. This is reflected in the eligibility criteria for CINP accreditation. The assembly of the credentialing body, Canadian Board of Intraoperative Neurophysiology Practitioners (CBINP), and development of the credentialing process and examination are the next key steps in the path to IONM accreditation. Members of the Canadian IONM community can also expect to be solicited for feedback on expectations for the profession, such as code of ethics, code of conduct, and professional standards of practice. Collaborative development of these items will be essential to ensure that the CINP designation is representative of the collective expectation for the individual holding the credential and performing IONM care.

CINP Update

The finalized version of the proposed pathway to become a Certified Intraoperative Neurophysiology Practitioner (CINP) has been presented to the CANM membership. It can be reviewed at **www.canm.ca**. After a 30 day review period, the FULL members of CANM received information on how to cast their vote on the proposal.

The results of the vote will be presented at the Annual General Meeting on Saturday September 15, 2018 in Calgary, AB at 16:30 MDT.

11th Annual IONM Symposium

Be sure to join us for the **11th Annual** CANM IONM Symposium

being held in Calgary at the foothills of the breathtaking Rocky Mountains! I am proud of the work our Organizing Committee has done incorporating your suggestions to provide you with an invaluable educational experience. Our symposium includes plenty of interactive programming allowing for individual discussions with experts in a variety of areas, as well as an opportunity to network and socialize. Our keynote speaker this year is Dr. Charles Dong who will enlighten the audience with his expertise on corticobulbar MEP and auditory evoked potential monitoring.

In addition to Dr. Dong, we have a first-rate combination of internationally recognized surgeons, anesthesiologists, and neuromonitorists who will share their extensive knowledge on wide range of topics, including the use of intraoperative EEG, monitoring in peripheral nerve and cardiovascular surgeries, and brain stem mapping. There will even be a demonstration of the use of Transcranial Magnetic Stimulation.

For your convenience, we encourage attendees to **book a room** at the venue, the **Hilton Garden Inn** Downtown Calgary, where we have reserved a block of rooms at a discounted rate.

Please visit the CANM website, **www.canm.ca**, for more symposium information and to view the entire program.

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

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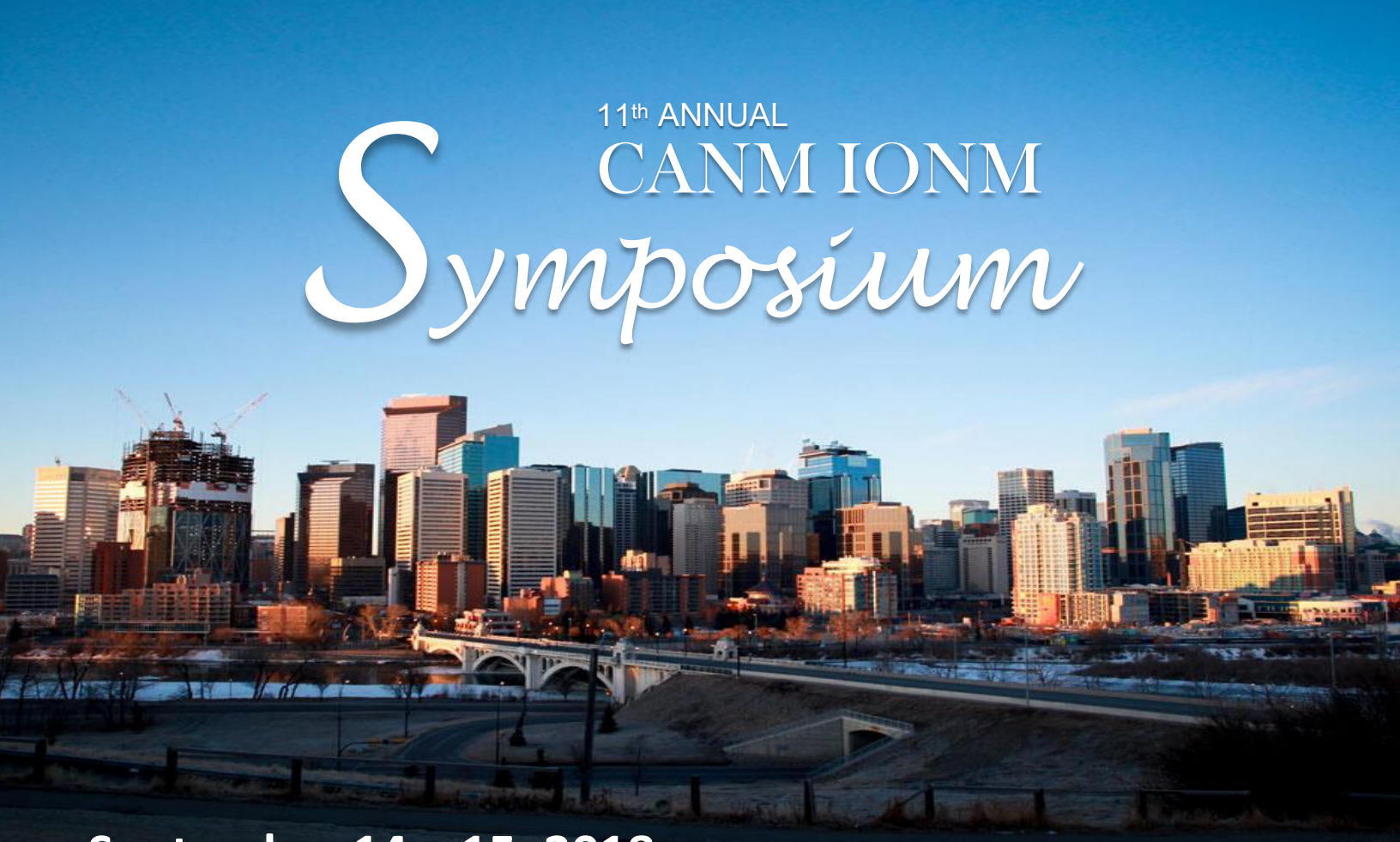

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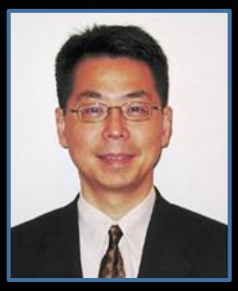
Keynote Address: Dr. Charles Dong, Clinical Associate Professor, Department of Surgery, University of British Columbia and Director of Intraoperative Neurophysiological Monitoring at Vancouver General Hospital.



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