



CANADIAN IONM NEWS

Official Newsletter of CANM

Message from the President

How many times have you been asked, “What exactly is it that you do”? As IONM professionals we become experts at answering this inquiry in varying levels of complexity depending on the audience but do you ever wish that the field of neurophysiological monitoring were more widely known?

Shining a spotlight onto the field of neurophysiological monitoring is part of CANM's mission and I am committed to promoting the excellent work that our Canadian IONM professionals are doing, but I need your help.

I challenge YOU, each and every one of you, to become active promoters of IONM. I challenge you to get out into the world and teach people about what it is you do! By working together, we will be able to reach a much wider audience and educate the population about IONM and its vital role in surgical safety of patients.

Let's use every opportunity to promote IONM. From personal conversations with friends and family to professional discussions with colleagues, you are gifted with the chance to explain the importance of neurophysiological monitoring. Take advantage of the presence of medical students and training physicians to showcase how IONM aids in the Canadian health care setting. Give a lecture at a meeting or deliver rounds at your hospital – the people you work with should hear more about your role. Why not write an article for your hospital newsletter, local paper, or university publication to bring awareness about IONM? Seek out opportunities to promote the profession during high school or university career days or reach out to guidance counselors with information about our educational program and careers in IONM. Educate the public and your patient's about the important role you play in their care and in reducing their risk of significant injury. Approach surgeons or institutions that do not routinely utilize IONM professionals and explain the value that IONM could bring to their practice. Let's take advantage of every opportunity, big or small, to become proactive advocates of IONM. By doing so, we will elevate awareness of neurophysiological monitoring to new heights.

So the next time you're asked, “What exactly is it that you do?”, don't miss the opportunity to promote yourself and the profession and to spread the word about the benefits of IONM, instead of just giving the quick answer.



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Canadian IONM Certification: Why?

The field of IONM is a dynamic and rapidly advancing service offered in many surgical centers all over the world. It is fast becoming the standard in patient care during a variety of neurological, orthopedic and vascular procedures. As we know, there is currently a worldwide shortage of IONM education and training as well as limited credentialing for IONM professionals. It is imperative for the ongoing development and advancement of the field that proper education and certification exist for IONM professionals from all backgrounds.

There are currently numerous IONM-related societies throughout the world, each with their own vision, mission, and values. General consensus between International (ISIN) and American Societies (ASNM, ASET, ABCN) is that there are two streams of credentialed IONM professionals. The CNIM (Certificate in Neurophysiological Intraoperative Monitoring) offered by ABRET (American Board of Registered EEG Technologists) in association with ASET (American Society of Electrodiagnostic Technologists) is the primary credential at the technologist level. The DABNM (Diagnostic American Board of Neurophysiologic Monitoring) offered by the ABNM is the primary credential for neurophysiologists. It is the opinion of these societies/boards that neurophysiologists oversee the technologist level IONM practitioners in the operating room. Education is provided through annual meetings and seminars held in a variety of locations throughout North America and Europe. Several private IONM companies in the United States offer in-house training, however there is no certificate level IONM training available in the United States or internationally.

In Canada, the Canadian Association of Neurophysiological Monitoring (CANM) is the national association representing IONM professionals. As members know CANM's mission is to "promote the field of intraoperative neurophysiological monitoring and foster the development of the profession through education and certification, so as to provide optimum patient care." Recently CANM partnered with the Michener Institute for Applied Health Sciences and launched a Certificate Program in IONM. In addition to this new education program, CANM is currently developing a Canadian accreditation exam in IONM. The importance of offering a national exam is two-fold; one to uphold CANM's mission and two, to support CANM's educational program. It is also CANM's vision that with appropriate experience, education and national credentialing, IONM practitioners from all backgrounds work as peers in the operating room. We need to continue to be leaders in the field of IONM, not only in terms of education but also in promoting a standardized inclusive credentialing system for IONM practitioners from all backgrounds. By achieving this, we can provide optimal patient care to all patients undergoing risky neurological, orthopedic and vascular surgeries within Canada and abroad.

Lindsay Mazepa, BSc, RET, REPT, CNIM, CLTM, HCMC

Electroneurophysiology Instructor

– British Columbia Institute of Technology

Electroneurophysiology Technologist

– Vancouver General Hospital

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Electrical Stimulation of the Nervous System: Safety Factors



Electrical stimulation of the nervous system is an integral element of intraoperative neuromonitoring (IONM). It is used as a start point in eliciting an evoked response which can then be recorded as it proceeds through the nervous system. It is routinely utilized in a multitude of IONM test modalities, including spinal cord mapping, and the mapping of eloquent brain function. It is also used in the identification of peripheral nerve roots. Electrical stimulation of the CNS is an essential part of IONM; however, there are safety factors that must be considered.

Constant voltage and constant current stimulators are available and deliver an electrical charge which is dependent on resistance. Ohms law states Voltage (V) = I x R where R is the resistance in Ohms and I is the current in amperes (A). Therefore a constant voltage stimulator will vary the current to deliver a set output, and a constant current stimulator will vary the voltage to deliver a set output.

Factors that have been tested experimentally to determine the safety limits of stimulation for repetitive suprathreshold electrical stimulation, are outlined below¹⁻³:

1. **current density** (J) = $\frac{\text{stimulation strength (mA)}}{\text{electrode size (cm}^2\text{)}}$
2. **charge per phase** (μC/phase) = stimulation strength (mA) x duration of a single pulse (μs)
3. **charge density** (μC/cm²/phase) = $\frac{\text{stimulation strength (mA)}}{\text{electrode size (cm}^2\text{)}}$ (duration of a single pulse (μs))
4. **total charge** (μC/cm²) = $\frac{\text{stimulation strength (mA)}}{\text{electrode size (cm}^2\text{)}}$ (pulse duration)(number of pulses)

Electrical stimulation utilized in most IONM equipment is typically a rectangular pulse that is monophasic or biphasic. Biphasic stimulation has a second phase of stimulation that is of the same duration and opposite polarity. The charge-balanced biphasic waveform can be used to reduce possible tissue damage.⁴

Animal studies of direct cortical stimulation have shown that charge density delivered to brain tissue is an important factor in determining the safety of cortical stimulation. These studies have suggested that the upper limit of charge densities that would be considered safe is 40 $\mu\text{C}/\text{cm}^2/\text{phase}$.³ Although intended to evaluate chronic direct stimulation, 40 $\mu\text{C}/\text{cm}^2/\text{phase}$ has been used as a threshold for electrical safety.¹ Gordon et al.⁵ found that direct cortical stimulation performed at several centres utilizing different methodologies produced charge densities of 159–796 $\mu\text{C}/\text{cm}^2/\text{phase}$ for peak currents of 2–5 mA. These high-charge densities appear to be safe because stimulations are intermittent and involve only several brief successive bursts of stimulation to each brain region tested. Current densities below 25 mA/cm² do not induce brain tissue damage even by applying high-frequency stimulation even over several hours.²

The duration of stimulation and the total charge are important parameters for transcranial electrical stimulation, TES safety criteria. Agnew et al.⁶ found that 4 hours of continuous stimulation at a charge density of 100 $\mu\text{C}/\text{cm}^2$ and a pulse rate of 50/s induced much more neural damage than did stimulation at the same charge density at 20/s.

Current density is independent of stimulation duration, and total charge reflects the product of current density and stimulation duration for a whole stimulation session, whereas charge per phase and charge density refer to only one pulse of a train of high-frequency suprathreshold stimuli applied over hours. Also the safety limits stated for charge per phase and charge density apply only if repetitive high frequency stimulation is given for several hours. This is the reason why charge density and charge per phase are not applicable to TES, because in TES only one (continuous) stimulus is given in a whole session.⁷

It is important to note that voltage does not stimulate neurons. It is charge that stimulates neurons. The stimulation device should guarantee a constant current density, since current density and not voltage is the relevant parameter for inducing neuronal damage¹ and a constant voltage device could result in unwanted changes of current density if resistance is unstable.

Possible mechanisms of electrical stimulation that could cause neuronal or brain tissue damage.¹

1. Charge transfer across electrode-tissue interface
 - a. Electrochemically produced toxic products (pH changes, chloride oxidation, oxidation of organics)
 - b. Electrode dissolution of products (soluble salts of metals)
2. Passage of current through tissue
 - a. Neuronal hyperactivity (or changes in membrane potentials)
 - b. Power dissipation (tissue heating)

Excitotoxicity is considered the major neuronal injury mechanism.^{1,3,8} Electrochemically produced toxic brain products and (metallic) electrode dissolution products can occur at the electrode-tissue interface caused by certain types of electrodes, such as stainless steel.⁹ Electrodes made of noble metals such as platinum safeguard against any such risk. Electrotoxicity at the electrode–tissue interface is not important in the case of transcranial stimulation, because stimulation electrodes and brain tissue do not come into direct contact.

Damaging effects due to cortical hyperactivity refer to the effect of high-frequency suprathreshold stimulation over hours.⁶ This prolonged stimulation-induced neuronal hyperactivity can induce significant disturbances in brain homeostasis, including sustained translocation of potassium and calcium between the extracellular and intracellular compartments.⁶ There is evidence that such electrolyte shifts themselves can precipitate neuronal injury.^{10–12} These factors are present even when the stimulating electrode is not in contact with the brain. The effects of transcranial electrical stimulation, TES, are subthreshold with regard to eliciting action potentials in neurons at resting membrane potential. Thus a damaging effect by

neuronal hyperactivity seems improbable. The critical current density or total charge entering the brain will only be about 50% of that directly under the electrode on the skin.¹³

It has also been found that cathodal TES is capable of inducing prolonged excitability reductions in the human motor cortex non-invasively. These changes are most probably localized intracortically.¹⁴

Direct tissue damage such as skin burns, can occur in areas of high electrical energy.¹⁵ This may occur with the use of surface electrodes that are dried out or are improperly applied. Needle electrodes that cause skin burns are usually due to monopolar cautery¹⁶ and are a result of a smaller surface area of the electrode increasing the current density.

Stimulation-induced axonal injury in the peripheral nerve has been shown to occur under prolonged, high-frequency electrical stimulation.¹⁷ Specifically, the sciatic nerves of cats were stimulated continuously for 8 hours with charge-balanced waveforms at 50 Hz and 2100–4500 μ A. Early axonal degeneration, followed by degeneration and phagocytosis occurred. This type of high frequency, high intensity, and long lasting electrical stimulus is not utilized in the OR.

Other Safety Considerations

Kindling, which refers to the induction of self-perpetuating epileptic foci that has been induced by repeated electrical stimulation, can occur in certain situations. Szelenyi et al. looked at the risk of intraoperative seizures associated with transient direct cortical stimulation in 129 patients with symptomatic epilepsy undergoing tumor resection within the central region.¹⁸ In 1 of 63 patients (1.6%) presenting with symptomatic epilepsy, a stimulation-associated seizure occurred, and 1 of the other 66 patients (1.5%) had a seizure. There was no increased risk of the occurrence of stimulation-associated seizures during surgery for patients with symptomatic epilepsy compared with those patients without. They also reviewed the literature and found, stimulation associated seizures are reported in 1.2% with the train-of-five technique and significantly more frequently in 9.5% with the 60-Hz, Penfield technique ($p=0.001$).

MacDonald reviewed the safety in cases that used TES for motor evoked potential monitoring, MEP, in more than 15000 cases.¹⁹ Adverse events were identified as 29 tongue/lip lacerations (0.19%), 1 mandibular fracture ($<0.01\%$), 5 seizures (0.03%), 5 episodes of cardiac arrhythmia, (0.03%), 2 scalp burns (0.01%), and 1 episode of intraoperative awareness ($<0.01\%$). His summary was based on literature review, unpublished clinical experience of several investigators, and information from Digitimer Ltd. Some of the seizures were spontaneous rather than stimulation induced. There were remarkably few adverse events.

Schwartz et al. reviewed the records of 18,862 consecutive patients who underwent spine surgery using repetitive transcranial electrical stimulation (RTES) to monitor motor function. RTES-related complications were identified in only 26 (0.14%) cases and all but one of these were tongue lacerations, most of which were self-limiting.²⁰ Their experience with this technique included patients with cardiac pacemakers, titanium craniotomy plates and screws, documented cardiac disease, and history of epilepsy, brain tumours, cerebral aneurysms, spinal cord tumours, and tethered spinal cords, among other pathologies. RTES did not appear to be associated with lowered seizure thresholds, elevated risk of cardiac arrhythmia or brain neuronal damage.

Electrode montages that could result in brainstem or heart nerve stimulation can be dangerous and should be avoided. After stimulating the brainstem, Lippold and Redfearn²¹ described one case of disturbed breathing, speech arrest and psychosis, and it cannot be ruled out completely that a current flow could modulate rhythmogenesis of the heart. Therefore the stimulation electrodes should be positioned so as to avoid current flow through the brainstem. Direct stimulation of the brainstem to map motor nuclei of cranial nerves may cause blood pressure alterations and cardiac arrhythmia; however no serious complications have been reported.

The methodology of monitoring the central nervous system during IONM has evolved tremendously over the years. Although there are risks with electrical stimulation of the nervous system, the benefits of IONM

in reducing neurological deficits far outweighs the risks. Special considerations should be taken in following the basic principles of electrical safety. Equipment used for stimulation should be well maintained and tested routinely. This will ensure that any risk associated with electrical stimulation will be reduced.

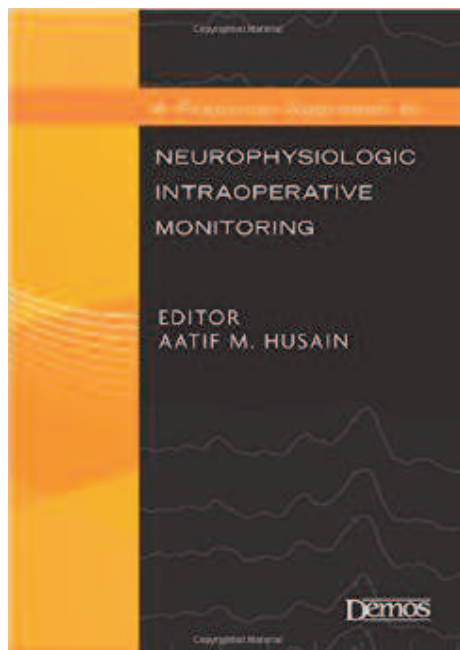
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Book Review: A Practical Approach To Neurophysiologic Intraoperative Monitoring

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EDITOR: AATIF M. HUSAIN, M.D.
ISBN-13: 978-1-933864-09-9

In *A Practical Approach to Neurophysiologic Intraoperative Monitoring* published by Demos Medical Publishing (copyright 2008), the editor, Dr. Aatif M. Husain, provides a 316-page, in-depth guide to intraoperative monitoring for common surgical procedures. Thirty-one authors contributed chapters to this book, including the editor, all of whom work in the field of IONM.

The book is broken into 2 sections: Basic Principles, and Clinical Methods. In Basic Principles there are 6 chapters that acquaint you with the operating room environment and how it differs from clinical testing. It covers a wide-range of practical material from equipment found in the OR to remote monitoring.

This section also covers basic anatomy and physiology, recording and stimulating parameters, and anesthetic considerations. Chapter 6 (A Buyer's Guide to Monitoring Equipment) is great for brushing up on the basics of analog and digital filtering, common mode rejection ratio, signal-to-noise ratio, and analog-to-digital conversion.

The second section, Clinical Methods, covers specific case types over 11 chapters. These chapters offer electrode placement, and filter settings to facilitate quality recordings. Guidance in peripheral and spinal potentials, MEPs, and D-waves are included. Schematics, photographs, and illustrations are plentiful and give the reader a basic understanding of what to expect during a case. This book is most helpful for spine cases, although coverage is given to carotid endarterectomy, microvascular decompression, cerebellopontine angle tumours, thoracic aortic surgery, and even a chapter covering epilepsy surgery.

This is a favourite book in my IONM library. The tone of the book is that of a friend guiding you through the entire process. It can be read cover to cover, or as a reference for specific topics. It is best for those just starting in the field, but holds up well when you need to refresh yourself before an uncommon case. Perhaps the greatest thing about this text is its affordability. It currently sells at Amazon.ca for around \$68 (with free shipping!). It is also available in Kindle format for a few dollars less.

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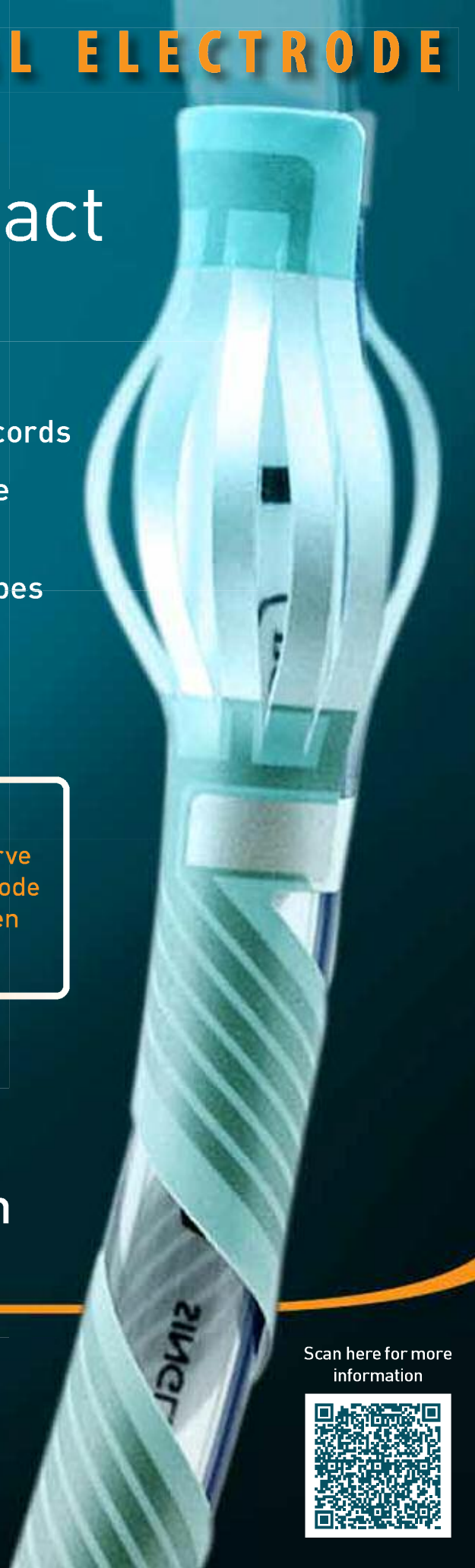
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Highlights from the 7th Annual CANM IOM Symposium

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*Dr. Stanley Skinner at the 7th Annual
CANM IOM Symposium in Toronto, ON.*



*Dr. Venkatraghavan (Anesthesiologist) at
the 7th Annual CANM IOM Symposium
in Toronto, ON.*



*Dr. Stephen Lewis (Orthopaedic Surgeon)
at the 7th Annual CANM IOM
Symposium in Toronto, ON.*

The CANM annual symposium is the epicenter of our educational calendar and over the years this meeting has evolved into the premiere Canadian conference for IONM professionals. Eager to carry on the success of our previous meetings, CANM hosted our 7th annual symposium on September 19–20 in Toronto, Ontario.

This year's dynamic and interactive meeting once again included a compilation of world renowned IONM experts, most notably our keynote speaker Dr. Stanley Skinner from Abbott Northwestern Hospital in Minneapolis, MN. The important yet often overlooked theme of "Patient Centered IONM" was the focal point of Dr. Skinner's keynote address and his comprehensive speech generated significant, constructive dialogue throughout the meeting.

While CANM hosted previous symposiums in Toronto, the 2014 meeting was an important pioneer in several respects. This was the first year in which neurosurgical registered nurses were in attendance, prompted by their appetite to learn more about IONM professionals with whom they work together with in the operating room theatre. Furthermore, for the first time CANM offered lectures on "Basic Engineering Principles" as well as "Adult Epilepsy," and "Spinal Deformity Surgery."

Following years of planning, chair of the CANM Education Committee, Sue Morris, announced the official commencement of the CANM - Michener Graduate Certificate Program in IONM which welcomed its inaugural students in September 2014.

Reflecting on the many achievements of this year's meeting, it is imperative that we recognize the hard work of symposium committee members Laura Holmes, Samuel Strantzas, Nancy Lu, Samantha Robertson, and Nicole Dinn. Acknowledgment should also be given to our corporate sponsors whose steadfast support of our association is always appreciated.

On behalf of the symposium committee and the CANM Executive Board I would finally like to extend my gratitude to our attendees who demonstrate year after year that passionate discussions surrounding IONM are alive and well in Canada.

Looking to 2015, it is with great enthusiasm that I announce that the beautiful Canadian city of Montreal has been selected as the location for next year's annual symposium.

I look forward to seeing you all in 2015!

Gina Bastaldo, MSc, CNIM
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2014 Symposium Committee
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