CANADIAN IONM NEWS
Official Newsletter of CANM

CANM
CANADIAN ASSOCIATION OF NEUROPHYSIOLOGICAL MONITORING

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Message from the President

The first cohort of the CANM-Michener Institute Graduate Certificate in Intraoperative Neurophysiological Monitoring is set to graduate in September 2016, marking a critically important milestone for IONM education in Canada. The second cohort will graduate in 2017 and we are busy reviewing admissions for the class that will complete the program in 2018. For the first time in Canadian IONM history, there is a clear and standardized educational pathway for newcomers entering the field and a strong professional development resource for established IONM practitioners.

The creation of this 2-year online IONM education program has been a gargantuan task and it would not have been possible without a small but fiercely dedicated and talented group of CANM members: Gina Bastaldo, Laura Holmes, David Houlden, Sam Strantzas, and Marshall Wilkinson. I would like to take this opportunity to offer my sincere thanks and congratulations to all of these individuals who have laboured long and hard over the last 2 years to oversee the creation of the CANM-Michener Graduate Certificate in IONM. What this team of volunteers has accomplished in a relatively short period of time is quite remarkable and the end result has garnered accolades from many prominent international IONM figures. Canada is becoming recognized as a leader in IONM education and I think we can all be proud of our burgeoning position on the IONM world stage. I would also like to thank the Education Committee's newest recruit, Francois Roy, for mentoring students and creating a positive learning experience in his role as an educational resource/tutor for many of the courses. Last, but certainly not least, I would like to thank the CANM members, international IONM colleagues, and other experts who generously shared their experience and knowledge as module writers for the certificate program.

Education has been a definite CANM theme this year and I would be remiss if I did not highlight the 2016 CANM *talks* webinar series and the tremendous contribution of its energetic coordinator, Nancy Lu. Already in 2016, Nancy has organized and hosted two well-attended CANM *talks* sessions. On May 12, Dr. James Zuccaro discussed "Practice Models within the Field of IONM," a hot button issue particularly south of the border. On June 22, our own Dr. Charles Dong presented a webinar entitled "Technique and Current Research on Facial MEPs." Dr. Dong was one of the first to publish on this topic and it was a real treat to watch him present his experience and some of his original data. If you have not attended a CANM *talks* Webinar, I encourage you to check them out because it is a rare opportunity to learn about specialized IONM-related topics and to liaise directly with colleagues and the presenting experts themselves.

CANM's intense focus on education in 2016 will culminate with the 9th Annual CANM IONM Symposium in Halifax, Nova Scotia on Friday, September 30 and Saturday, October 1. The Symposium Organizing Committee, under the very experienced leadership of Laura Holmes, has put together a top-notch list of speakers including our keynote, Dr. John Dormans. Dr. Dormans is the chief of orthopedics at the Texas Children's Hospital and a professor of orthopedic surgery at Baylor College of Medicine. Included among his many achievements, Dr. Dormans has served as president of the Pediatric Orthopedic Society of North America (POSNA) and the Scoliosis Research Society (SRS). He has published more than 340 articles, authored more than 140 chapters and written 5 books. Of particular interest to IONM practitioners is his publication entitled, *Establishing a Standard of Care for Neuromonitoring during Spinal Deformity Surgery*[1] In addition to delivering his keynote address, Dr. Dormans will participate in a panel discussion specifically addressing issues around standards of care for IONM in spine surgery along with Drs. David Houlden and Ron El-Hawary (chief of orthopedic surgery at the IWK Health Centre, Halifax NS).

I encourage you to visit the CANM website to view the entire program for the 2016 CANM IONM Symposium. You will quickly see that it promises to be an intellectually stimulating and highly interactive event. Also, do not forget that the event is being held in one of Canada's most storied cities and one that boasts a down home Maritime vibe that can only be appreciated first hand. So please come to Halifax this fall and combine learning with a healthy dose of genuine East Coast charm.

Susan Morris, PhD Neurophysiologist
President, CANM Executive Board
IWK Children's Health Program
CDHA Division of Neurosurgery
Assistant Professor (Surgery) Dalhousie University
Halifax, Nova Scotia

Reference

Dormans JP. Establishing a standard of care for neuromonitoring during spinal deformity surgery. Spine (Phila Pa 1976) 2010;35(25):2180–5.

New CANM Members

INTERNATIONAL MEMBER
David Morledge – Boise, Idaho

ASSOCIATE MEMBER
Jessica Cherwick – Calgary, AB

9TH ANNUAL

CANM IONM Symposium

September 30th - October 1st

Halifax, Nova Scotia

Please join us for the 9th Annual CANM IONM Symposium. This year's meeting will be held in historic Halifax, Nova Scotia September 30 – October 1, 2016 at the Prince George Hotel.

Halifax is a beautiful seaside city, rich in history and tradition. The Prince George Hotel is set in the charming city centre, close to the Halifax Citadel, a short walk from the waterfront, and near the Pier 21 National Historic Site.

We are pleased to have Dr. John Dormans as our keynote speaker to discuss *Establishing a Standard of Care for IONM in Spinal Deformity Surgery*. Dr. Dormans is the chief of pediatric orthopedic surgery at the Texas Medical Center in Houston, TX. He is internationally recognized and respected as both physician and scholar, having published more than 340 articles, written five books, and participated as an invited lecturer in nearly 50 countries.

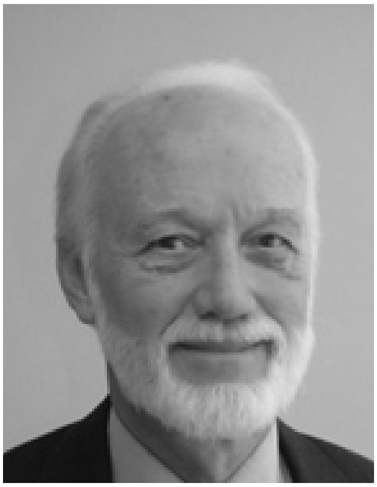
The CANM Annual Symposium has earned the reputation of being a lively and interactive learning experience, and this year's meeting will not disappoint. The program includes lectures and presentations on standard of care in IONM, functional neurosurgery, spinal deformity surgery, as well as case presentations and guided discussions.

As an accredited provider, Dalhousie University, Continuing Professional Development, has designated this as a continuing professional development activity for up to **15.00** credit hours as an accredited group learning Section 1 activity as defined by the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada.

For more information on registration, payment options, and programming please visit the CANM website at http://www.canm.ca/symposium.html.

We look forward to seeing you in Halifax!

Sincerely,
2016 CANM Symposium Organizing Committee



Dr. Charles Yingling, PhD, D.ABNM
CEO of Golden Gate Neuromonitoring
Pioneer in the field of IONM

In 2010, Dr. Charles Yingling served as the Keynote Speaker at the 3rd Annual CANM IONM Symposium in Banff, Alberta. CANM is once again privileged to have this renowned leader in IONM share his perspective on the current state of neuromonitoring.

Education has always been at the core of Dr. Yingling's career. He obtained his PhD in neurobiology from Rice University and later became a Professor at University of California, San Francisco (UCSF). It is at UCSF that Dr. Yingling gained international recognition as an innovating leader of IONM and he is credited for launching their first neuromonitoring program. He is also celebrated for his many educational contributions in journal publications and textbook chapters.

During the early years of neuromonitoring Dr. Yingling was instrumental in the development of prominent IONM associations. He served as a founding member of American Society of Neurophysiological Monitoring (ASNM) and the American Board of Neurophysiologic Monitoring (ABNM). Dr. Yingling also lent his support to CANM during the early years of our formation. Now many years later we are grateful that he has agreed to participate in our ongoing Interview Series.

Gina Bastaldo, MSc, CNIM
Secretary, CANM Executive Board
Editor-in-Chief *Canadian IONM News*
Toronto Western Hospital, University Health Network
Toronto, Ontario

Gina Bastaldo (GB): You are credited with launching the IONM program at the University of California at San Francisco (UCSF), which you managed for nearly two decades. Can you describe the steps you enacted to ensure the success and longevity of your renowned team?

Charles Yingling (CY): The first thing I did was say yes! The Neurosurgery Department had become aware of IONM from the early literature and discussions with their colleagues at other institutions and, of course, wanted to do this at UCSF as well. They first had an engineer build a box, which fried a nerve. They called neurology, who sent a tech to the OR, who was quickly overwhelmed by 60 Hz. Finally, they called me. I was running an EEG and evoked potential research lab in the Department of Psychiatry, and they asked "can you do that in the OR?". I said yes, and spent the weekend building a rolling evoked potential system with equipment borrowed from the lab. The following Monday, I recorded SEPs from an electrode implanted in the thalamus for control of chronic pain. That was my first IONM case!

The next day, I was asked if I would like a joint appointment in the neurosurgery department, who would pay half my salary without the necessity to write grants to cover it. I thought for a few microseconds, and answered yes. Soon the questions multiplied: can you monitor this? Can you monitor that? I always answered yes, sometimes then having to do quite a bit of scrambling to figure out what I had just committed myself to. (This was in the early days of IONM, and there was not yet a lot of literature to go by.)

Soon the calls started coming more frequently, and I was being asked to monitor two cases at the same time. I still said yes, but running back and forth between two rooms was not sustainable, so I asked if I could hire one of my graduate students part-time to help out. It was harder to get them to say yes, but eventually I had an assistant. As more surgeons became interested, and we figured out how to monitor more types of cases, we all said yes more frequently and by the turn of the century we had seven full-time people, monitoring over 1200 cases per year.

Another type of question was frequently asked: “can you write that up?” In academic institutions, publications are the most valuable currency, both for promotions and prestige. Surgical residents quickly learned that IONM was a wide-open field, and almost everything we did could be turned into a publication. Soon we had a constant stream of publications, and of graduating residents who went into faculty positions all over the country, bringing with them their commitment to IONM and enhancing the reputation of UCSF in the process.

Finally, I hired and trained the most intelligent and hard-working people I could find. It is a source of great pride to me that over a decade after I left UCSF, the neuromonitoring service that I founded continues to be recognized as an exemplary model of quality patient care as well as academic productivity.

GB: Many professionals working outside of the U.S. report a lack of financial support as a primary obstacle in establishing a new IONM program. Did budgetary restrictions exist when you created your program in the American privatized healthcare system? Or were there other hurdles you had to overcome? What advice do you have for those saddled with the responsibility of establishing an IONM program at their institution?

CY: When I began the program at UCSF, budgetary questions never even came up. In the early 1980s, there were no billing codes for IONM. My salary was determined by academic rank, which was determined by publications, and the busy Neurosurgery department where I was based had no shortage of clinical income. Needless to say, this changed over time, particularly when the billing code 95920 was introduced to specifically cover “intraoperative neurophysiological testing”. Fortunately, this was never a problem I had to deal with, since the UCSF administration understood the importance of neuromonitoring and was always supportive. Others may not be so lucky.

In the United States, reimbursement is complicated by the division of each billing code into technical and professional components. The technical component is considered the responsibility of the hospital, and cannot be billed directly to a third-party insurance carrier. Thus, a hospital must either provide this service with in-house staff or else contract with an outside service. On the other hand, the professional component can be billed to a third-party, but typically this is only reimbursed if billed by a licensed physician. CMS (Medicare) has recently determined that they will only pay one hour’s worth of professional fees per hour, even if the supervising professional is simultaneously responsible for multiple cases. It is probably only a matter of time until private insurers adopt the same policy. This will create a significant problem for the “one neurologist, multiple technologists” model of service delivery that has become very common in the US, whether the supervising professional is in-house or connected remotely via the Internet.

GB: Recent discussions in journal publications and IONM symposiums have focused on oversight models and the differing skill levels required to independently monitor a surgical case. Your IONM team at the UCSF consists of IONM professionals with ample years of experience and credentialing. Can you describe the neuromonitoring oversight model that your team follows and how it was crafted to deliver safe quality patient care?

CY: During my years at UCSF, I was indeed fortunate to have a high-level team consisting primarily of doctoral level individuals, ultimately with DABNM certification. The need for oversight was thus minimized, and we could assign personnel to the various cases based on their interests and experience. And since I was virtually always in the hospital, it was easy for me to walk around the corner and provide a second pair of eyes whenever questions or unusual situations arose.

Furthermore, we were fortunate to work with a group of sophisticated and knowledgeable surgeons, who were perhaps more involved in the details of monitoring that is always the case. For example, one of the first neurosurgeons I worked with had an undergraduate degree in electrical engineering from MIT. He spoke fluent electricity, and as I learned to speak passable surgery we communicated quite easily.

One of the biggest problems I often encounter in medical legal expert witness work is a failure to communicate effectively. This is often a problem in both directions- a technologist may know how to attach electrodes and run the monitoring computer, but cannot talk to the surgeon in a way that inspires confidence and thus may be ignored. The surgeon, all the other hand, may have little or no understanding of the principles of monitoring, which may be seen as insurance in the event of a bad outcome and resulting legal action. As the demand for monitoring continues to grow, adequate training and education for surgeons, anesthesiologists, and monitoring personnel will become much more important

GB: As an experienced leader in IONM you have performed intraoperative neuromonitoring on thousands of neurosurgical patients. Do you routinely (or have you ever) initiated preoperative visits with patients? What are the inherent benefits / disadvantages of an IONM practitioner employing this practice and providing patients with IONM information prior to their surgery?

CY: In my early days at UCSF, I had more frequent interaction with patients, and sometimes performed preoperative evaluations the day before surgery. Later, to save money patients began to arrive at the hospital only on the morning of surgery, and this made interactions more difficult due to time constraints and/or premedication. After this, I typically only met patients after they were wheeled into the OR and only a brief introduction was possible. I would jokingly introduce myself as their electrician, nodding towards the anesthesiologist and saying "I see you've already met your plumber". This bit of levity helped put the patients at ease. I would briefly explain what my role was, and they would typically respond that they already knew who I was since the surgeon had gone over monitoring during their preoperative visit. This is of course another advantage of having knowledgeable and involved surgeons.

If the hospital context permits the monitoring personnel to converse with the patient prior to surgery, the most important thing is to reassure the patient with a sense of calm professionalism that everything possible will be done to keep them safe during surgery. Some patients are terrified, will never understand what monitoring is about, and primarily need a calm reassurance that they are in good hands. Other patients may be curious, possibly even joking, and have lots of questions. It is important that each patient be seen as an individual human being, not yet another spinal fusion case, and met on a personal level with communication appropriate to their needs. Undergoing surgery is a very stressful time for every patient, regardless of how well or poorly they seem to be handling it.

GB: A decade ago, instructional courses in intraoperative neuromonitoring were in short supply despite a strong appetite for education in this growing field of allied healthcare. Recently, there has been an increase of IONM educational content offered online via webinars and interactive courses. From your perspective, how has this surge of online material impacted the landscape for those practicing IONM today?

CY: Online training via the Internet has tremendous potential, as yet incompletely realized. For a few years, while I was director of education for one of the large private monitoring companies in the US, I conducted two online seminars each month. One was a journal club format, where we discussed a recent publication that had been circulated the week before so that everyone had a chance to read it first. The second was a case review, where we discussed a recent case that had either had a bad outcome or where we had identified problems with the way it was monitored. Roughly 60 people attended each session in real time, at each session was recorded so that those who were still in the OR during the presentation could review it later. This was a tremendous educational tool, partly because attendance was mandatory so there was a cumulative effect.

More recently, I have attended several online webinars on different topics, some related to monitoring and some to new surgical techniques. However, my attendance at these is hit or miss depending on my personal schedule, and I suspect this is true for many others as well. Ideally, such webinars would be archived at a central website, so that over time a complete training program comprising both basic principles and advanced topics could be accessed as needed. In principle, such an online repository with appropriate tracking and testing materials could comprise the academic component of a complete training program in IONM. Ideally, such a program would be sponsored by an accredited university, and offer certificate and or degree programs. Of course, practical hands-on training in the OR is also necessary, but this could be accomplished at any appropriate location with qualified mentors and an appropriate volume and diversity of cases.

This of course could benefit not only people currently practicing IONM, but also new recruits wishing to enter the field.

GB: You have devoted a significant portion of your career to IONM mentorship and training. In your opinion what are the most pressing challenges that await professionals entering the field of IONM today that did not exist 10 years ago?

CY: As the demand for neuromonitoring services has grown, more people are entering the field with relatively little background in fields such as neuroanatomy and digital instrumentation technology. The challenge for education and training programs is to teach newcomers to the field not merely how to place electrodes, run a monitoring system, and identify waveforms, but also to understand the underlying anatomical and technical principles. Without this foundation, troubleshooting and interpretation of intraoperative changes are much more difficult.

A second issue is the explosive growth of monitoring during spinal procedures, compared with a relatively constant volume of cases involving craniotomies for intracranial tumors or cerebral aneurysms. There are ample opportunities to gain experience monitoring common spinal procedures, but relatively fewer chances to participate in cases involving cranial nerve monitoring or cortical mapping techniques. Hopefully, increasing use of online training materials, including videos, will help with this problem.

GB: Education and communication are often touted as essential factors required for successful collaboration between surgeon, anesthesiologist and IONM practitioner. Over your distinguished career have you identified other lesser known factors that are responsible for effective cooperation between the surgical team?

CY: The key word in this question is "team". In his excellent book *The Checklist Manifesto*, Atul Gawande pointed out that surgical complications decrease when the various OR personnel function as a team. This sense of teamwork can be fostered during the pre-incision surgical timeout by each person identifying themselves by name and role. Simply knowing people's names improves communication and the ability to function together as a team.

Unfortunately, this has not always been the case. I once reviewed a policy and procedure manual which used the metaphor of a totem pole to describe the hierarchy in the OR. It explicitly stated that the neuromonitoring tech was "the low man on the totem pole" and encouraged keeping a low profile, so as not to interfere with anyone else's performance of their job. Needless to say, this directive did not make people feel empowered to speak up when they noticed a possible change in waveforms. The concept of the surgeon as "captain of the ship" has some validity, but if MEPs are suddenly lost following a surgical maneuver, the person responsible for neural monitoring had better be the loudest voice in the room!

In short, effective communication in the OR is only possible when all members of the team know one another and understand each person's respective role. Ideally, the team members have worked together frequently enough to feel comfortable communicating clearly and effectively when, inevitably, the fan gets hit. This is less of a problem in institutional settings where the same group of people work together on an ongoing basis. It becomes a larger issue in community hospital settings where mobile monitoring services may send different personnel to each case. This is perhaps more of a problem in the United States than Canada

GB: The majority of current publications surrounding the field of IONM are dedicated to the use Transcranial Electric Motor Evoked Potentials (MEP). As an ardent contributor to IONM research can you recommend another topic in neuromonitoring that has been overlooked and is in need of further study from researchers?

CY: Despite the large number of publications about motor evoked potentials, there is still no consensus concerning appropriate criteria for surgical alert: all or none, amplitude change, threshold change, or waveform morphology. Studies directly comparing sensitivity and specificity of these various measures are unfortunately quite rare, and more attention needs to be paid to determining optimal criteria.

An issue that has received much attention recently concerns the quality of evidence for studies supporting IONM. The "gold standard" of controlled, randomized, double-blind clinical trials is not applicable in many contexts. For example, it has been pointed out that there are no controlled trials to prove the efficacy of parachute usage when confronted with gravitational challenge! Similar considerations apply to IONM, where randomized controlled trials are not feasible for both practical and ethical reasons. To the extent that the economic viability of neuromonitoring may depend on literature supporting its efficacy, more publications using alternative methods for evidence-based decision-making are needed.

GB: In continuation from the previous question, can you suggest a topic that perhaps requires more consideration at IONM symposiums and scientific meetings?

CY: My unscientific survey of my memories of recent meetings is that topics tend to cluster around the middle of the spectrum - specifics of monitoring techniques as applied in various clinical contexts. What seem to be relatively less frequent are discussions of fundamentals such as basic neuroanatomy, neurophysiology, and instrumentation as mentioned above, and also meta-topics such as levels of evidence and appropriate staffing models.

GB: There has been considerable debate within the IONM community regarding the use of "Remote Monitoring". Many have expressed apprehension with this practice as it allocates neuromonitoring oversight to an individual who is not physically in the operating room. Do you share these concerns? Do you believe that "Remote Monitoring" can increase surgeons' access to IONM?

CY: I personally hate the term "remote monitoring", do not use it, and in fact don't believe there really is such a thing. Neural monitoring is a professional patient care activity that of necessity must take place in the operating room where the patient is undergoing surgery. The person actually in the OR is the only one in the position to have situational awareness of the overall picture, including the progress of the operation itself, changes in anesthetic agents and/or physiological parameters, and of course the neural monitoring data itself. And of course, this person is the only one in the position to be able to communicate directly with the surgeon, anesthesiologist, or other OR personnel.

That said, there is a role for what I would prefer to call "remote consultation". Particularly in complex or less common cases, a second pair of eyes and a second opinion can be quite valuable. However, the person rendering the second opinion must have the experience upon which to base such an opinion. Possession of an advanced degree or a license to practice medicine is not sufficient unless supported by extensive personal experience in the type of case being monitored. A common saying is that it takes between 10,000 and 20,000 hours of practice to achieve mastery of a complex skill, whether it be playing the violin or performing neurosurgery. (Note that this is equivalent to 5-10 years at 40 hours per week). Obviously, at this point in time there are not enough people with this level of experience to staff every OR needing neuromonitoring.

Rather than pretending that every case is “monitored” remotely, which is often a polite fiction for justifying a bill for professional fees, a more appropriate model would be to have high level expertise available when needed for each case. Fortunately, most monitored cases are relatively uneventful and a remote consultant is not needed for the entire duration of the case. On the other hand, having such an expert available to confirm appropriate and adequate baselines, and to provide consultation and backup only when needed, is in my view a much more appropriate model than the pretense that every case is actually being monitored by a remote professional online.

To summarize, monitoring happens in the operating room, not remotely, but online consultation can be very useful.

GB: Both neurosurgeons and IONM practitioners have suggested that neuromonitoring may have a negligible impact on minor neurosurgical procedures (eg: lumbar discectomies). In your practice, have you made similar observations on the overuse of IONM? What are the possible advantages or disadvantages of this service being allocated to “less” risky surgical cases?

CY: The question about overuse of IONM is part of a larger discussion extending to the overuse of some surgical procedures. A recent article in the New York Times was titled “Why ‘useless’ surgery is still popular”. It reviewed recent published studies on spinal fusion, vertebroplasty, and meniscus surgery, all of which concluded that none of these procedures had supporting evidence of even moderate quality. I think it is inevitable that as more such studies are published, there will be a trend both towards such surgeries becoming less frequent, and for IONM to be less frequently used in lower risk cases.

The potential advantages of this are greater availability of experienced IONM personnel for more critical, high risk cases. The disadvantage is that even simple cases can unexpectedly turn into nightmares. I am aware of one case involving an uncomplicated lumbar discectomy during which the surgeon inadvertently nicked the aorta and the patient died. It will never be possible to completely eliminate all unfortunate outcomes, even if every surgical case could be monitored by an expert with 20,000 hours’ experience. With limited resources, difficult decisions must always be made, hopefully based on the best available evidence rather than personal preference or monetary concerns.

GB: As a founding member of several prominent IONM associations (ASNM, ABNM, ABNMP) you played an integral role in their early development. Can you provide some insight into how these associations must adapt in the coming years to meet the growing demand for neuromonitoring?

CY: When ASNM was founded over 25 years ago, we hoped that it would become the primary society for people involved in neuromonitoring, and that a concerted effort might lead to a pathway for non-physicians to be reimbursed directly for their patient care activities. Unfortunately, most of this dream never came true. For the most part, physicians who became involved in neuromonitoring continued to identify primarily with their existing disciplinary societies, such as ACNS. Similarly, technologists moving into neuromonitoring from EEG or evoked potential laboratories continued to identify primarily with ASET. To some extent, I think, ASNM was viewed as elitist by the technologist community and its membership remained relatively small.

This perception was possibly reinforced when the DABNM certification was created, during my term as president of ASNM. The requirement of an advanced degree perpetuated a two-tier system for non-physicians. Again, for the most part, physicians did not bother with this new certification, since they were already licensed and board certified by their own specialty bodies. Thus, the DABNM, although prestigious, became a niche credential primarily attained by PhD’s and foreign MDs. After more than 15 years, today there are still fewer than 200 people holding DABNM certification. In contrast, there are over 3500 individuals certified as CNIM.

This imbalance in numbers has led, in the United States at least, to the most common model for delivery of IONM services being a technologist (hopefully CNIM certified) in the OR, with a licensed physician acting as the official supervising professional. As discussed above, this has all too frequently placed the primary burden for monitoring on the technologist in the OR, who may or may not have the experience and professional standing to communicate effectively with the surgeon.

United we stand, divided we fall. Diverse backgrounds, lack of formal and standardized training programs, turf battles, and changing reimbursement practices have created a challenge for all individuals and organizations seeking to optimize patient care during surgery. There need to be more pathways for individuals at the technologist level to gain the training, experience, and degrees or credentials to be recognized as allied healthcare professionals, rather than being relegated to the role of "just a" tech. People with doctoral degrees in the neurosciences should be encouraged to consider neuromonitoring as an alternate career path, rather than a series of soft-money postdoctoral appointments while hoping for the rare faculty position. Physician and non-physician professionals should set aside their differences and work together to create new models for online consultation and quality control.

Finally, surgeons should endeavor to learn enough about neuromonitoring to utilize it effectively. After all, the surgeon is the one individual who knows the patient's medical history, current symptoms and pathology, surgical anatomy, and the details and current status of the surgical procedure itself. To the extent that the surgeon also understands the principles of neuromonitoring well enough to interpret and understand the implications of changes in monitored signals, he/she will be in the best position to make surgical decisions based on this data. Increased cooperation between surgical societies and those representing neuromonitoring would be a major step in the right direction.

Thoughts on the Spine Neuromonitoring Evidence Base

Dr. Stanley Skinner, MD, FASNM

Although the evidence supporting intraoperative neuromonitoring (IONM) to prevent spinal cord/nerve root injury remains mixed and confounded, the preponderance of the evidence justifies IONM in many of the varied settings of spine surgery. Nevertheless, guidance by the Scoliosis Research Society that, "…intraoperative neurophysiological spinal cord monitoring is not investigational and is… an integral part of surgical deformity correction procedures…" and similar avowals have not generated universal acceptance of IONM in spine surgery. Limitations of the published evidence (and related delivery models) in IONM persist:

- Very few controlled trials
- Unknowable confounders within and disagreement among super-sized retrospective datasets
- Confounded tabulation of test results (especially reversed/recovered signal changes)
- Unsettled MEP alert criteria
- Injury prediction as a necessary but insufficient measure of effectiveness
- Inter-related problems of intraoperative communication and injury prevention
- Disparate IONM delivery models which likely vary in effectiveness

This article, abstracted from a more thorough review in preparation, will touch upon injury prediction versus injury prevention, intraoperative communication, and a path forward to enrich the IONM evidence base.

When the generic term "neuromonitorist" is used in this article, it means the individual or team the surgeon trusts to expertly execute IONM modalities and interpret the results. As importantly, in the event of an alarm, the appropriately credentialed neuromonitorist team member communicates those results with sufficient cogency and urgency to realize the best chance for signal recovery and a good outcome.

Getting from Injury Prediction to Injury Prevention: The Communication Mandate

A major systematic review has shown that spine IONM testing regimes can, indeed, predict neurological injuries.[1] Using evidence-based methodology of the American Academy of Neurology, four "Class I" studies of MEP and/or SEP in various settings were reviewed. The three MEP-era Class I studies specifically reported the MEP alert criterion as 50–60% MEP amplitude loss. This very sensitive alert indeed generated, as expected, no false negative reports among the studies (sensitivity = 1.0). However, the combined positive predictive value (for serious neurologic injury) was only 0.30 (false positive predictive value = 0.70). Some unknowable fraction of "false" reports were likely reversed/recovered signal changes which may have been associated with intraoperative prevention of a genuine injury. Post hoc analysis of these reversed/recovered signal changes might uncover additional "true positive" suspects.[2] Unfortunately, a prediction analysis which looks at differences in outcomes (no injuries with negative testing, 30% risk serious of injury with positive testing) incompletely informs us about the role IONM might play in injury prevention. We are left to hope that surgeons, understanding this data when acknowledging an IONM alert, will intervene appropriately. But, there is no guarantee of that.

The Wiedemayer study remains the single study which reviewed surgeons' responses to IONM alerts.[3] Decisions to respond (or not) to an alert were most often made based on context: does the alert fit what the surgeon sees within the wound (a recent surgical manipulation, for example) or hears from the anesthesiologist (low BP, for example). Only about 50% of alerts were followed by an intervention. Another likely factor in surgeons' hesitance to intervene is cognitive bias: predispositions which restrain the surgeon from changing the course surgery. In the event of an alert, deeply instilled beliefs and previously learned rules of thumb (heuristics) come to mind first. The surgeon may inwardly determine that the best in-wound option is to, "Keep doing what I am doing (what I have always done)" with the often heard response, "I haven't done anything (apart from what I have always done)."[4,5] It turns out that it may be only the trusted neuromonitorist who can slow the surgeon down, introduce crucial pathophysiological and probabilistic thinking, and achieve the best result.[6]

The series of events leading to an outcome can be conceived as an interventional cascade: test → interpretation communication intervention → outcome.[5] *Communication* has proven to be the key element to medical error avoidance in clinics and hospitals (ORs in particular).[7] Ironically, the practice of IONM has so far avoided serious discussion of neuromonitorist-surgeon communication and related situational awareness (especially in the US where "remote" IONM is predominant). This, despite the fact that cogent and urgent communication from a trusted neuromonitorist colleague may counteract the surgeon's own understandable predispositions and bias. When an alert is credibly conveyed in a setting of familiarity and collegiality, the neuromonitorist's special body of knowledge may elevate merely accurate prediction to a higher plane… injury prevention and improved outcomes.

A group of orthopedic spine surgeons, who evidently recognize this communication/collegiality imperative, have created an IONM checklist for use during deformity correction of the "stable spine."8 Highlighted within the checklist is a call to "summon" the "senior neurologist or neurophysiologist" in the event of an IONM alarm. Because all or nearly all of the surgeon authors work in major teaching hospitals around the US and Canada, each very likely enjoys routine access to a trusted neuromonitorist colleague. Therefore, this checklist sets the framework for collaboration among peers: a surgeon/anesthesiologist/neuromonitorist co-practice.

Shoring Up the Spine IONM Evidence Base

It may seem overly scrupulous or even immaterial to suggest that IONM delivery models bear any relationship to evidence. However, medical error avoidance scholarship, especially within high-stakes settings (like ORs), points to one crucial element among inter-acting colleagues: trust based communications. Models which honor such relationships may be expected to enjoy better post-operative outcomes. Put another way, there is no evidence whatever in the literature that inter-collegial aloofness, deference, or anonymity improves outcomes.

Within trust-based collegial settings, the possibility of extending the IONM evidence base to answer remaining questions exists. There appears to be consensus that IONM is indicated in spinal deformity correction and, in many quarters, intramedullary spinal cord tumor resection as well. Likewise, few experts may recommend routine IONM during lumbar micro-discectomy. The great middle-ground of spine IONM (1–2 level cervical decompressions, for example) still requires better evidence. Misplaced demands for prospective controlled trials, which may put enrolled patients at risk for catastrophic spinal cord injury, should be resisted on ethical grounds. A multi-institutional registry of propensity-score matched cases in which "IONM is done" versus "IONM never intended = not done" could answer many questions (including models of care effectiveness).[5] This effort would require a significant effort among dedicated investigators who understand that payers and many surgeons see the current evidence base as incomplete. Properly equipoised controlled IONM trials are possible in a few areas (like lumbar pedicle screw insertion) where the outcome stakes are not as high.

In summary, there is an unfulfilled need to address problems with some IONM care delivery models. Gaps in the IONM evidence base also need attention. The essential argument of this brief review is that these two issues are irrevocably tied together by the interventional cascade: accurate diagnostic testing must be effectively communicated to motivate surgical intervention, prevent potential injury, and secure the best possible outcome.

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Intraoperative Spinal Cord Monitoring using Low Intensity Transcranial Stimulation to Remove Post-Activation Depression of the H-Reflex

Andrews JC, Stein RB, Jones KE, Hedden DM, Mahood JK, Moreau MJ, Huang EM, Roy FD.
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Introduction

Hoffmann (H) reflexes and F-waves can be used to monitor the integrity of segmental motor pathways in the spinal cord.[1] Reflex monitoring, however, only provides indirect information about pyramidal and extrapyramidal connectivity. To provide a more direct measure of descending motor function, segmental responses can be paired with a descending motor evoked potential (MEP).[2,3] Pairing acts to reduce the firing threshold of the alpha-motoneuron and enables both pathways to be monitored using weaker stimuli. This may help limit the amount of patient movement. To complement these approaches, work from our lab has shown that an MEP can facilitate spinal reflexes that would otherwise be absent because of post-activation depression.[4,5] Post-activation depression is seen as the gradual recovery of the H-reflex, in part, due to the transient reduction in transmitter release from the primary afferent (Ia) terminal in the period that follows the first H-reflex. Modulation of this pathway therefore provides of a possible new target for detecting the arrival of the corticospinal input at the sacral spinal cord. In the present study, we aimed to examine whether transcranial electrical stimulation (TES) could modulate post-activation depression under general anesthesia, and secondly, examine the stability of the interaction during routine IONM.

Methods

Twenty pediatric patients were tested during spinal deformity correction surgery. Post-activation depression was elicited in the medial gastrocnemius using paired H-reflexes delivered 10–150 ms apart. The second (depressed) H-reflex was conditioned with TES. Total intravenous anesthesia consisting of propofol, ketamine and remifentanil were administered in 18/20 patients, and sevoflurane (0.2-0.5 MAC) was included in 2/20.

Results

The interaction was optimized at the start of each procedure. Most often, the inter-pulse interval was set to 100 ms and TES was delivered 7.5 ms before the second tibial nerve stimulus. When TES consisted of a train-of-five (approximately 275 V), the conditioning effect was large. With these parameters, TES also produced visible MEPs. The interaction was nonetheless maintained when TES was decreased to 2 pulses (typically) and MEPs were rarely observed. Using this weak TES stimulus, the interaction was observed in 20/20 patients. Overall, the interaction was stable throughout the surgical procedures and no visible movement was observed within the surgical field in 19/20 procedures.

Conclusions

Post-activation depression provides a predictable method of suppressing the H-reflex. The modulation of post-activation depression using low-intensity TES enabled the CST to be monitored with little to no patient movement. The information acquired from this interaction is qualitatively similar to what would be obtained using D-wave monitoring given that it only assesses spinal motor function in a global sense rather than providing comprehensive coverage of myotomes.

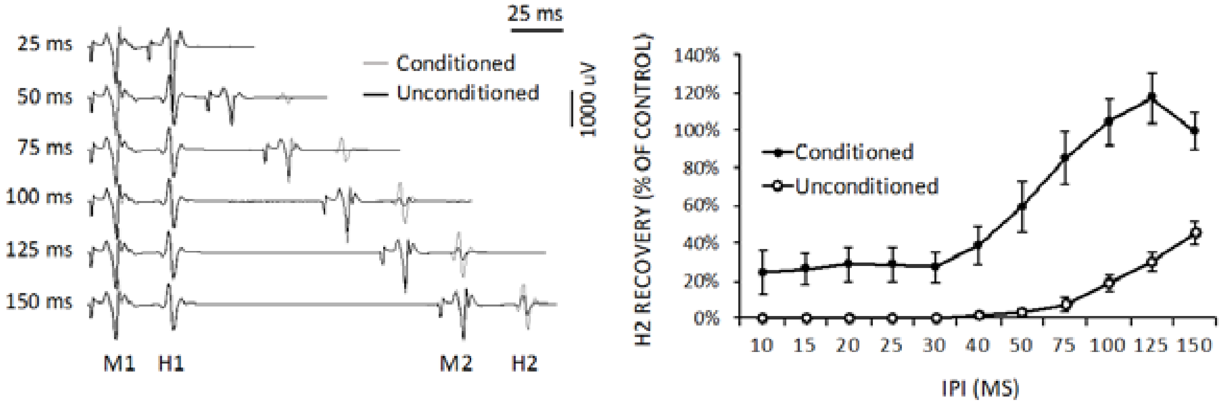

Figure 1. TES was used to condition the depressed H-reflex in the medial gastrocnemius. Single patient data (left) and group average (right). Recovery was most prominent at inter-pulse interval (IPI) ≥ 40 ms. Labels show the first and second M and H-waves.

Future Directions

The technique has been tested within pediatric patients. Future work may involve patients with pre-existing neurological deficits where MEP monitoring is limited and H-reflexes may even be enhanced. The results can be further compared to the other afferent facilitatory approaches introduced during IONM.

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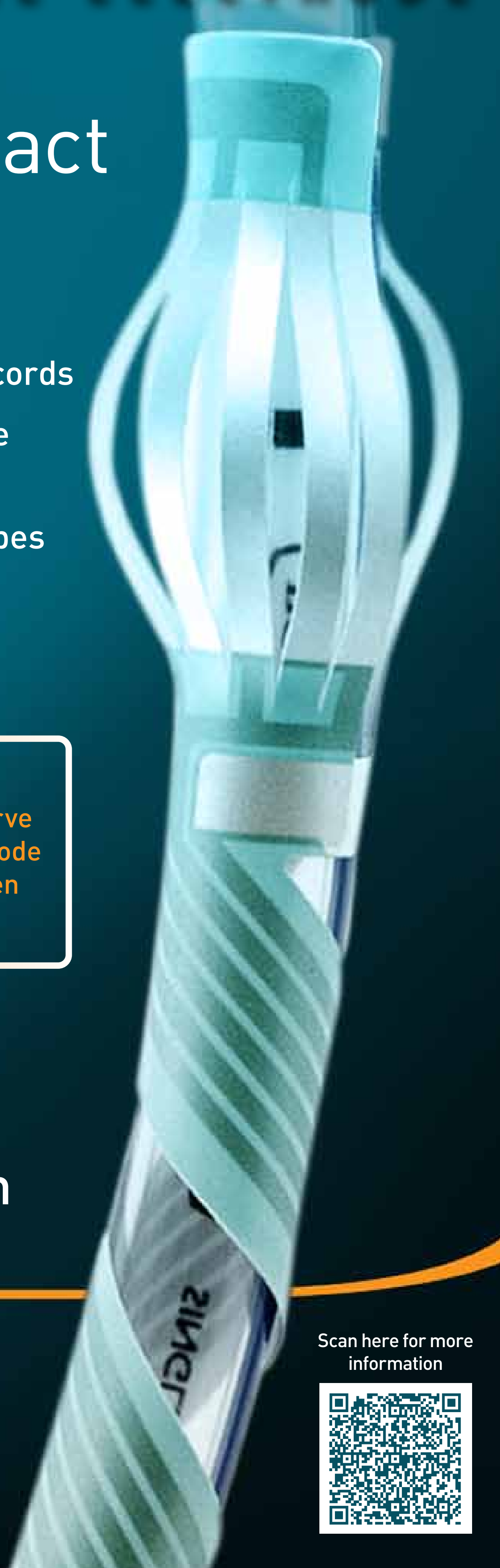

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