



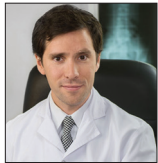
Original Article

## Barriers of neurophysiology monitoring in spine surgery: Latin America experience

Alfredo Guiroy<sup>1</sup>, Marcelo Valacco<sup>2</sup>, Martin Gagliardi<sup>1</sup>, Juan Pablo Cabrera<sup>3</sup>, Juan Emmerich<sup>4</sup>, Gaston Camino Willhuber<sup>5</sup>, Asdrubal Falavigna<sup>6</sup>

<sup>1</sup>Department of Orthopedics, Hospital Español, Mendoza, Argentina, <sup>2</sup>Department of Orthopedics, Hospital Churrucá Visca, <sup>4</sup>Department of Neurosurgery, Hospital Español de La Plata, La Plata, <sup>5</sup>Department of Orthopedics, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina, <sup>3</sup>Department of Neurosurgery, Hospital Clínico Regional, Concepción, Chile, <sup>6</sup>Department of Neurosurgery, University of Caxias do Sul, Caxias do Sul, Rio Grande do Sul, Brazil.

E-mail: Alfredo Guiroy - [alfreguiroy@hotmail.com](mailto:alfreguiroy@hotmail.com); Marcelo Valacco - [marcelo.valacco@gmail.com](mailto:marcelo.valacco@gmail.com); Martin Gagliardi - [martingagliardi32@gmail.com](mailto:martingagliardi32@gmail.com); Juan Pablo Cabrera - [jpccvolley@hotmail.com](mailto:jpccvolley@hotmail.com); Juan Emmerich - [dremmerich@hotmail.com](mailto:dremmerich@hotmail.com); Gaston Camino Willhuber - [gaston.camino@hospitalitaliano.org.ar](mailto:gaston.camino@hospitalitaliano.org.ar); Asdrubal Falavigna - [asdrubalmd@gmail.com](mailto:asdrubalmd@gmail.com)



**\*Corresponding author:**

Alfredo Guiroy,  
Spine Unit, Department of  
Orthopedic, Hospital Español  
de Mendoza, 965 San Martín  
Av. Mendoza, Argentina.  
PC 5501.

[alfreguiroy@hotmail.com](mailto:alfreguiroy@hotmail.com)

Received : 31 January 2020

Accepted : 14 February 2020

Published : 30 May 2020

**DOI**

10.25259/SNI\_44\_2020

**Quick Response Code:**



### ABSTRACT

**Background:** Intraoperative neurophysiological monitoring (IOM) has become valuable in spine surgery. Unfortunately, it is not always available in many spine centers, especially in developing countries. Our aim was to evaluate the accessibility and barriers to IOM in spine surgery in Latin America.

**Methods:** We designed a questionnaire to evaluate the characteristics of surgeons and their opinions on the usefulness of IOM for different spine operations. The survey was sent to 9616 members and registered users of AO Spine Latin America (AOSLA) from August 1, 2019, to August 21, 2019. Major variables studied included nationality, years of experience, specialty (orthopedics or neurosurgery), level of complexity of the hospital, number of spine surgeries performed per year by the spine surgeon, the types of spinal pathologies commonly managed, and how important IOM was to the individual surgeon. General questions to evaluate use included accessibility, limitations of IOM usage, management of IOM changes, and the legal value of IOM. The results were analyzed and compared between neurosurgeon and orthopedics, level of surgeon experience, and country of origin.

**Results:** Questionnaires were answered by 200 members of AOSLA from 16 different countries. The most common responses were obtained from orthopedic surgeons (62%), those with more than 10 years of practice (54%); majority of surgeons performed more than 50 spine surgeries per year (69%) and treated mainly spine degenerative diseases (76%). Most surgeons think that IOM has a real importance during surgeries (92%) and not just a legal value. Although surgeons mostly considered IOM essential to scoliosis surgery in adolescents (70%), thoracolumbar kyphosis correction (68%), and intramedullary tumors (68%), access to IOM was limited to 57% for economic reasons. Of interest, in 64% of cases, where IOM was available and significant change occurred, the actual operative procedures were significantly altered.

**Conclusion:** Despite the fact that 68% of spine surgeons believe IOM to be indispensable for complex spine surgery, cost remains the main barrier to its use/availability in Latin America.

**Keywords:** Evoked potentials, Intraoperative neurophysiological monitoring, Latin America, Spine surgery, Spine

### INTRODUCTION

Intraoperative multimodal neurophysiological monitoring (IOM) helps to prevent new neurological deterioration in real time, particularly during high complex spine surgeries.<sup>[13,18]</sup> Many spine surgeons

This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

©2020 Published by Scientific Scholar on behalf of Surgical Neurology International

agree regarding the usefulness of IOM in deformity cases and spinal cord tumors.<sup>[6-8]</sup> However, appropriate patient selection for IOM and its cost is the main factors limiting its use.

This study evaluated the current frequency of use/availability of IOM for spine surgeons operating in Latin America.

## MATERIALS AND METHODS

### Study design

This cross-sectional study was performed using an IOM survey. The survey was sent to spine surgeons who were members of AO Spine Latin America (AOSLA).

### Intraoperative monitoring questionnaire

AO Spine has more than 1400 members and more than 9000 associated members in Latin America with clinical and research interest in spine care. Questionnaires were mailed to assess surgeon characteristics and opinions regarding the usage and barriers to IOM in spine operations. Variables analyzed included nationality, age, specialty, years of experience, level of complexity of the hospitals, number of surgeries per year, type of pathology, and level of importance given by the surgeon to IOM. General questions evaluated regarding IOM accessibility encompassed; barriers to usage, attitudes after IOM changes, and the legal value [Table 1]. Further details regarding the administration of questionnaires are found in [Table 1].

### Statistical analysis

Surgeons' opinions were compared by country, years of experience, and specialty. Comparisons were performed using the Fisher's exact test. *Post hoc* comparisons were adjusted using the Bonferroni procedure. Data were processed and analyzed using SPSS version 22.0 (IBM, Armonk, New York, USA).

## RESULTS

### Surgeon characteristics

The questionnaire was answered by 200 members of AOSLA; they were from different countries, and the number of participants in each country, along with their specialties and years of experience, was assessed [Table 2]. The majority of the participants were orthopedic surgeons (62%) in practice for longer than 10 years (54%), most performed more than 50 spine surgeries a year (69%), and mainly managed degenerative disease (76%).

### Barriers for IOM usage

The most common limitations to access/use of IOM were economic reasons (57%) followed by availability (20%) and finally lack of trained neurophysiologists (16%).

**Table 1:** Questionnaire form. The questionnaire in Portuguese and Spanish version was sent 3 times by e-mail to 9616 members and registered users of AO Spine Latin America at 10-day intervals between August 1, 2019, and August 29, 2019. Two hundred surgeons answered.

Country
Years of practice
<5
5–10
>10
Specialty
Orthopedics
Neurosurgery
Level of the hospital
University hospital
Level I trauma
Private practice
Number of surgeries performed yearly
<25
25–50
>50
Pathology more frequently performed
Degenerative
Trauma
Tumors
Deformity
Importance given to intraoperative neurophysiology monitoring (IOM)
In adolescent idiopathic scoliosis, I think IOM is
Indispensable
Important
Unnecessary
In adult spinal deformity, I think IOM is
Indispensable
Important
Unnecessary
In thoracolumbar kyphosis correction, I think IOM is
Indispensable
Important
Unnecessary
In asymptomatic cervical myelopathy, I think IOM is
Indispensable
Important
Unnecessary
In symptomatic cervical myelopathy operated by an anterior approach, I think IOM is
Indispensable
Important
Unnecessary
In symptomatic cervical myelopathy operated by a posterior approach, I think IOM is
Indispensable
Important
Unnecessary
In primary vertebral tumors, I think IOM is
Indispensable
Important
Unnecessary

(Contd...)

**Table 1:** (Continued).

In spinal metastasis with signs of spinal cord compression, I think IOM is
Indispensable
Important
Unnecessary
In spinal metastasis without spinal cord compression, I think IOM is
Indispensable
Important
Unnecessary
In intradural spinal tumors, I think IOM is
Indispensable
Important
Unnecessary
In lumbar degenerative pathologies, I think IOM is
Indispensable
Important
Unnecessary
About access to IOM
I always have access
I have access occasionally
I never have access
Does the intraoperative neurophysiology findings modified your preoperative plan at any time?
Yes
No
What do you do if you have an unexpected loss of intraoperative potentials?
I finish the surgery immediately
I think it is probably a neurophysiological problem
I think it is probably an anesthetic issue
I use a checklist to identify false positives
I think IOM is only legally important, not surgically
True
False
Which are the main limitations to the use of IOM in your hospital?
Economic
Logistics
Lack of trained neurophysiologists
Other reasons (which: _____)

More surgeons considered IOM to be essential for adolescent scoliosis surgery, thoracolumbar kyphosis correction, and removal of intramedullary tumors [Table 3]. There were, however, no differences in surgeons with more versus fewer years of practice/experience, between use if IOM by surgeons from different countries or between orthopedists versus neurosurgeons.

Notably, 64% of surgical plans were altered intraoperatively due to significant IOM changes. About 89% used a checklist in case of loss of IOM; 5% finished the procedure, 4% thought that it was a neurophysiological problem, and 1% attributed it to anesthetic issues.

**Table 2:** Surgeon's answers regarding importance giving to IOM in different pathologies.

Country	No. (%)
Brazil	51 (25.5)
Argentina	47 (23.5)
Mexico	32 (16)
Colombia	15 (7.5)
Chile	13 (6.5)
Peru	8 (4)
Panama	6 (3)
Ecuador	5 (2.5)
Venezuela	5 (2.5)
Bolivia	4 (2)
Costa Rica	3 (1.5)
Rep. Dominicana	3 (1.5)
Cuba	2 (1)
Guatemala	2 (1)
Uruguay	2 (1)
Paraguay	2 (1)
Years of experience (years)	
<5	48 (24)
5–10	44 (22)
>10	108 (54)
Specialty	
Orthopedic	124 (62)
Neurosurgeon	76 (38)

The vast majority of the surgeons answered that IOM was of real clinical importance during surgeries (92%) and not just used to address legal issues.

## DISCUSSION

IOM has been widely used as an important adjunct in spine surgery. In a large, nationally representative dataset,<sup>[10]</sup> IOM was found to result in better clinical outcomes during even noncomplex spine surgery. In Latin America, most surgeons found IOM useful, but access was limited for mostly economic reasons (57%), lack of availability (20%), and/or trained neurophysiologists (16%). Specifically, in Brazil, spine surgeons found that only 29.6% routinely used IOM, but that in 68% of cases, they did not access to it.<sup>[9]</sup>

### Use of IOM during spine surgery in different countries

Different countries found varying rates for using/advocating IOM for spine surgery.

A Germany-Austria-Switzerland study involved 575 centers with 63.8% response rate (e.g., mostly spine centers). IOM was more heavily used by neurosurgery versus orthopedics.<sup>[17]</sup> The majority of spine surgeons used IOM to remove intramedullary spinal cord tumors. Further, it was routinely used in 82.3% of cases, used it

**Table 3:** Surgeons answered about the use, access, and limitations to IOM. Also two questions about losing of intraoperative potentials.

Question	Total: 200, n (%)		
	Indispensable (%)	Important (%)	Unnecessary (%)
<b>Relevance to intraoperative monitoring in</b>			
Adolescent idiopathic scoliosis	140 (70)	58 (29)	2 (1)
Adult scoliosis	108 (54)	84 (42)	8 (4)
Thoracolumbar kyphosis	136 (68)	60 (30)	4 (2)
Symptomatic cervical myelopathy	98 (49)	76 (38)	26 (13)
Symptomatic cervical myelopathy operated by anterior approach	64 (32)	86 (43)	50 (25)
Symptomatic cervical myelopathy operated by posterior approach	82 (41)	88 (44)	30 (15)
Primary vertebral tumors	80 (40)	102 (51)	18 (9)
Spinal metastasis with spinal cord compression	42 (21)	96 (48)	62 (31)
Intradural tumors	136 (68)	56 (28)	8 (4)
Lumbar degenerative pathologies	18 (9)	80 (40)	102 (51)

in special situations (8.2%), or never used (9.5%).<sup>[3,5]</sup> In Canada, most spine surgeons believed that IOM was an important adjunct to improve safety during spine surgery. The availability of the equipment/personnel was the main factor impacting its use.<sup>[14]</sup> Of interest, it was equally used by neurosurgery and orthopedics, used more in practice settings (private or academic) and for surgeons with more years in practice/experience. In the US, the massive 296% increase in IOM usage in spine operations over the past decade was largely attributed to increased performance of more complex spine operations: 31,762 cases in 2008 to 125,835 cases in 2014.<sup>[12,19]</sup> IOM was more likely to be used in urban teaching hospitals (72.9%) versus nonteaching hospitals (25.0%) or rural centers (2.2%).<sup>[8]</sup> Multiple studies had documented the efficacy of somatosensory evoked potentials in decrease the risks of intraoperative neural injury during pediatric/adult scoliosis surgery/ deformity correction.<sup>[2,4,16]</sup>

### IOM in cervical pathology

Motor-evoked potentials can be especially useful in anterior cervical spine surgery where motor tracts are particularly at risk. In the USA, from 2007 to 2014, 15,395 patients underwent an ACDF in the treatment of spondylotic myelopathy/radiculopathy, a patient group considered low risk compared with patients with fractures, tumors, or deformities. However, the overall incidence of neurological injuries after ACDF surgery was 0.27%. IOM was used in 2627 patients (17.1%), and there was a significant decrease in the use of ACDF from 22.8% in 2007 to 4.3% use in 2014.<sup>[1]</sup> In addition, another group of authors has performed a systematic search to identify studies on IOM use for anterior cervical spine surgery, and they limited usefulness for IOM for ACDF as there was no difference in the risk of neurological injury with or without IOM.<sup>[2]</sup>

### Cost-benefit relation

A point of permanent debate is the cost-benefit relation of IOM.<sup>[11]</sup>

In government hospitals and university hospitals, there is greater access to IOM versus private hospitals since they have trained personnel to perform IOM. Only a single case is needed with a bad neurological result to justify many IOM cases.<sup>[15]</sup>

### CONCLUSION

It is essential to better educate Latin America spine surgeons regarding the clinical value and cost/benefit ratio of performing safer IOM monitored spine surgery.

### Acknowledgments

AOSLA for survey distribution, writing assistance, and proofreading.

### Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### REFERENCES

1. Ajiboye RM, D'Oro A, Ashana AO, Buerba RA, Lord EL, Buser Z, et al. Routine use of intraoperative neuromonitoring during ACDFs for the treatment of spondylotic myelopathy

- and radiculopathy is questionable: A review of 15,395 cases. *Spine (Phila Pa 1976)* 2017;42:14-9.
2. Ajiboye RM, Zoller SD, Sharma A, Mosich GM, Drysch A, Li J, *et al.* Intraoperative neuromonitoring for anterior cervical spine surgery: What is the evidence? *Spine (Phila Pa 1976)* 2017;42:385-93.
  3. Avila EK, Elder JB, Singh P, Chen X, Bilsky MH. Intraoperative neurophysiologic monitoring and neurologic outcomes in patients with epidural spine tumors. *Clin Neurol Neurosurg* 2013;115:2147-52.
  4. George J, Das S, Egger AC, Chambers RC, Kuivila TE, Goodwin RC. Influence of intraoperative neuromonitoring on the outcomes of surgeries for pediatric scoliosis in the United States. *Spine Deform* 2019;7:27-32.
  5. Ghadirpour R, Nasi D, Iaccarino C, Giraldo D, Sabadini R, Motti L, *et al.* Intraoperative neurophysiological monitoring for intradural extramedullary tumors: Why not? *Clin Neurol Neurosurg* 2015;130:140-9.
  6. Korn A, Halevi D, Lidar Z, Biron T, Ekstein P, Constantini S. Intraoperative neurophysiological monitoring during resection of intradural extramedullary spinal cord tumors: Experience with 100 cases. *Acta Neurochir (Wien)* 2015;157:819-30.
  7. Kumar N, Vijayaraghavan G, Ravikumar N, Ding Y, Yin ML, Patel RS, *et al.* Intraoperative neuromonitoring (IONM): Is there a role in metastatic spine tumor surgery? *Spine (Phila Pa 1976)* 2019;44:E219-24.
  8. Laratta JL, Shillingford JN, Ha A, Lombardi JM, Reddy HP, Saifi C, *et al.* Utilization of intraoperative neuromonitoring throughout the United States over a recent decade: An analysis of the nationwide inpatient sample. *J Spine Surg* 2018;4:211-9.
  9. Netto MB, Neto MI, Ferreira RJ, Zuiani GR, Cavali PT, Veiga IG, *et al.* The reality of using intraoperative neurophysiologic monitoring among Brazilian spine surgeons. *Coluna Columna* 2012;11:310-4.
  10. Ney JP, van der Goes DN, Nuwer MR. Does intraoperative neurophysiologic monitoring matter in noncomplex spine surgeries? *Neurology* 2015;85:2151-8.
  11. Ney JP, van der Goes DN, Watanabe JH. Cost-benefit analysis: Intraoperative neurophysiological monitoring in spinal surgeries. *J Clin Neurophysiol* 2013;30:280-6.
  12. Nixon AT, Smith ZA, Lawton CD, Wong AP, Dahdaleh NS, Koht A, *et al.* Bilateral neurological deficits following unilateral minimally invasive TLIF: A review of four patients. *Surg Neurol Int* 2014;5:S317-24.
  13. Nuwer MR, Dawson EG, Carlson LG, Kanim LE, Sherman JE. Somatosensory evoked potential spinal cord monitoring reduces neurologic deficits after scoliosis surgery: Results of a large multicenter survey. *Electroencephalogr Clin Neurophysiol* 1995;96:6-11.
  14. Peeling L, Hentschel S, Fox R, Hall H, Fournay DR. Intraoperative spinal cord and nerve root monitoring: A survey of Canadian spine surgeons. *Can J Surg* 2010;53:324-8.
  15. Sala F, Dvorak J, Faccioli F. Cost effectiveness of multimodal intraoperative monitoring during spine surgery. *Eur Spine J* 2007;16 Suppl 2:S229-31.
  16. Sala F, Palandri G, Basso E, Lanteri P, Deletis V, Faccioli F, *et al.* Motor evoked potential monitoring improves outcome after surgery for intramedullary spinal cord tumors: A historical control study. *Neurosurgery* 2006;58:1129-43.
  17. Siller S, Raith C, Zausinger S, Tonn JC, Szelenyi A. Indication and technical implementation of the intraoperative neurophysiological monitoring during spine surgeries—a transnational survey in the German-speaking countries. *Acta Neurochir (Wien)* 2019;161:1865-75.
  18. Sutter M, Deletis V, Dvorak J, Eggspuehler A, Grob D, Macdonald D, *et al.* Current opinions and recommendations on multimodal intraoperative monitoring during spine surgeries. *Eur Spine J* 2007;16 Suppl 2:S232-7.
  19. Tamkus A, Rice KS, Kim HL. Intraoperative neuromonitoring alarms: Relationship of the surgeon's decision to intervene (or not) and clinical outcomes in a subset of spinal surgical patients with a new postoperative neurological deficit. *Neurodiagn J* 2017;57:276-87.

**How to cite this article:** Guiroy A, Valacco M, Gagliardi M, Cabrera JP, Emmerich J, Willhuber GC, *et al.* Barriers of neurophysiology monitoring in spine surgery: Latin America experience. *Surg Neurol Int* 2020;11:130.