INTRODUCTION

Intraoperative multimodal neurophysiological monitoring (IOM) helps to prevent new neurological deterioration in real time, particularly during high complex spine surgeries.[13,18] Many spine surgeons...
agree regarding the usefulness of IOM in deformity cases and spinal cord tumors.[6-8] 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 | Specialty        | Level of the hospital | Number of surgeries performed yearly | Pathology more frequently performed | Importance given to intraoperative neurophysiology monitoring (IOM) |
|------------------|-------------------|------------------|-----------------------|--------------------------------------|------------------------------------|---------------------------------------------------------------|
|                  | <5                | Orthopedics      | University hospital   | <25                                  | Degenerative                      | In adolescent idiopathic scoliosis, I think IOM is             |
|                  | 5–10              | Neurosurgery     | Level I trauma        | 25–50                                | Trauma                            | Indispensable                                                  |
|                  | >10               |                  | Private practice      | >50                                  | Tumors                            | Important                                                      |
|                  |                   |                  |                       |                                      | Deformity                         | 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      |
|                  |                   |                  |                       |                                      |                                   | Indispensable                                                  |
|                  |                   |                  |                       |                                      |                                   | Important                                                      |
|                  |                   |                  |                       |                                      |                                   | Unnecessary                                                     |
|                  |                   |                  |                       |                                      |                                   | In symptomatic cervical myelopathy operated by a posterior      |
|                  |                   |                  |                       |                                      |                                   | Indispensable                                                  |
|                  |                   |                  |                       |                                      |                                   | Important                                                      |
|                  |                   |                  |                       |                                      |                                   | Unnecessary                                                     |
|                  |                   |                  |                       |                                      |                                   | In primary vertebral tumors, I think IOM is                     |
|                  |                   |                  |                       |                                      |                                   | Indispensable                                                  |
|                  |                   |                  |                       |                                      |                                   | Important                                                      |
|                  |                   |                  |                       |                                      |                                   | Unnecessary                                                     |

(Contd...)
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.

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,[10] 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.[9]

**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.[17] 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...
in special situations (8.2%), or never used (9.5%).[3,5] 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.[14] 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.[12,19] IOM was more likely to be used in urban teaching hospitals (72.9%) versus nonteaching hospitals (25.0%) or rural centers (2.2%).[6] 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.[2,4,16]

**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.[1] 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.[2]

### Cost-benefit relation

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

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.[15]

### 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.

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### Declaration of patient consent

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

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### Conflicts of interest

There are no conflicts of interest.

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