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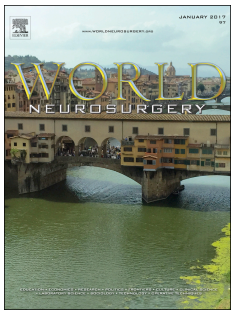

The Need for Clinical Practice Guidelines in Assessing and Managing Perioperative Neurologic Deficit: Results from a Survey of the AOSpine International Community

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Level of evidence: 4

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Abstract

Objectives: There is no standardized approach to assess and manage perioperative neurologic deficit (PND) in patients undergoing spinal surgery. This survey aimed to evaluate the awareness and usage of clinical practice guidelines (CPGs) as well as investigate how surgeons performing spine surgeries feel about and manage PND, and how they perceive the value of developing CPGs for the management of PND.

Methods: An invitation to participate was sent to the AOSpine International community. Questions were related to the awareness, usage of CPGs and demographics. Results from the entire sample and subgroups were analyzed.

Results: Of 770 respondents, 659 (85.6%) reported being aware of the existence of guideline(s), and among those, 578 (87.7%) acknowledged using guideline(s). Overall, 58.8% of surgeons reported not feeling comfortable managing a patient who wakes up quadriplegic after an uneventful multilevel posterior cervical decompression with instrumented fusion. While 22.9% would consider an immediate return to the operating room, the other 77.1% favored conducting some kind of investigation/medical intervention first, such as obtaining a MRI (85.9%), administrating high-dose corticosteroids (50.2%) or increasing the MAP (44.7%). Overall, 90.6% of surgeons believed that CPGs for the management of PND would be useful and 94.4% would be either likely or extremely likely to use these CPGs in their clinical practice.

Conclusions: The majority of respondents are aware and routinely use CPGs in their practice. Most surgeons performing spine surgeries reported not feeling comfortable managing PND. However, they highly value the creation and are likely to use CPGs in its management.

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Introduction

Although the occurrence of a perioperative neurologic deficit (PND) is an intrinsic risk to any spine surgery, it is one of the most feared complications among surgeons. It is associated with potential devastating physical and psychological consequences for patients and their families, as well as significant societal burden. Technically, PND results from any physiologic insult to the central or peripheral nervous system. However, in the context of spinal surgery, it often refers specifically to any direct or indirect physiologic insult to the spinal cord, cauda equina or isolated nerve root intraoperatively or shortly after surgery causing neuronal dysfunction, which may lead to temporary or permanent motor, sensory or autonomic impairment.[1] A review of the literature highlighted the paucity of evidence on the incidence, the factors associated with PND as well as the measures taken to abate such complications.[2] Nonetheless, it seems that PND is relatively rare; the overall incidence is estimated to range from 0 to 3% depending on the type of pathology, spinal region and surgical procedure.[3,4] For example, data from the Scoliosis Research Society (SRS) on surgical complications in patients treated for adolescent idiopathic scoliosis identified 31 postoperative neurologic deficits among 6,334 cases (0.5%). Of these patients, none suffered a complete injury, 61% fully recovered and 39% exhibited partial or no neurologic recovery.[5] However, the recent prospective, multicenter, international ScoliRisk Study (a joint effort of AOSpine and the SRS) showed that, overall, approximately 20% of patients operated for a complex adult spinal deformity with normal preoperative American Spinal Injury Assessment (ASIA) lower extremity motor scores (LEMS) experienced a significant decline in their lower extremity motor function at hospital discharge, six weeks and six months postoperatively. In contrast, patients with abnormal preoperative ASIA LEMS improved significantly at six months after surgery.[6]

It is likely that potential PND will be increasingly recognized given the increase use of multimodality intraoperative neuromonitoring in both high-risk and routine spinal surgical procedures. Multimodality intraoperative neuromonitoring has been shown to be sensitive and specific for detecting PND.[7] Consequently, it allows for immediate action to be taken to potentially reverse the course of neurologic dysfunction. However, the methods used to detect intraoperative neurophysiologic or electrophysiologic changes, the optimal combination of neuromonitoring modalities, and their overall clinical reliability have yet to be established.

Clinical practice guidelines (CPGs) are defined as “statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefit and harms of alternative care options”.[8] CPGs aim to integrate and synthesize the best evidence of efficacy and safety as well as patient values and preferences in the light of a consensus panel of experts to ensure a rational approach to patients’ management and thereby reducing variations in service delivery. High-quality CPGs are among the bases of efforts to improve healthcare by promoting high standards of patient care, conserve resources and guide healthcare policies.

In 2009, the American Academy of Orthopedic Surgeons (AAOS) reviewed the literature and formulated a number of methods to prevent or minimize the risk of PND during idiopathic scoliosis surgeries, including thorough patient evaluation, preoperative planning and intraoperative neuromonitoring, and proposed an assessment and treatment algorithm for

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intraoperative changes of >50% amplitude and >10% latency in somatosensory evoked potentials (SSEPs) / Transcranial motor evoked potentials (tcMEPs) signals.[9] However, no consensus-based guidelines were derived. Subsequently, Vitale et al.[10] developed an intraoperative checklist and a consensus-based CPG on (1) the use of intraoperative neuromonitoring, (2) the minimal change in neuromonitoring signal that should be considered a significant alert, and (3) the role of the wake-up test in patients with a stable spine undergoing deformity correction.[10] Consequently, it might not be appropriate to apply their recommendations to other high-risk spinal cases such as severe degenerative cervical myelopathy (DCM) and intramedullary tumours.

To date, general CPGs do not exist for the assessment and management of PND in adult spine surgery. The goals of this survey were threefold: (1) to evaluate the awareness and usage of any CPGs in clinical practice, (2) to investigate how surgeons performing spine surgeries feel about and manage PND and (3) to evaluate how these surgeons would value the creation of CPGs in the assessment and management of PND and their likelihood of using this CPG in their clinical practice. Given the tremendous amount of time, work and cost associated with generating CPGs, the results of this survey will inform whether the development of CPGs for the assessment and management of PND in adult spine surgery targets a need and meets the wishes of spine surgeons.

Methods

Survey design, study population and sample

This cross-sectional study employed an online survey that was administered to members of the AOSpine International Community from six geographic regions (Africa, Asia Pacific, Europe, Latin America, Middle East, and North America) targeting surgeons and trainees performing adult spine surgery. As of September 30th, 2016, the total number of members of the AOSpine international community were as follows: 2,191 in Asia Pacific, 1,431 in Latin America, 1,389 in Europe, 608 in Middle East, 569 in North America, and 102 in Africa.

Survey questionnaire development, pilot study, distribution, data collection and analyses

A 30-question English language questionnaire was created using SurveyMonkey (www.surveymonkey.net, Palo Alto, USA). As indicated in the electronic mail (e-mail) of invitation, the first question asked members whether they were interested in completing the survey. Those who were not interested were directed to the second question which aimed to determine the reason why they chose not to participate.

An internal pilot study involving ten staff spine surgeons, spine fellows and neurosurgery residents from the University of Toronto, Toronto, Canada was conducted to ensure that (1) the survey questions were clear and adequately addressed the study objectives, and (2) the online survey interface was working properly. The survey questionnaire was modified according to the comments gathered from this pilot study.

Once the AOSpine International survey board approval was obtained, an invitation e-mail was sent to the AOSpine International Community on September 21st, 2016 that included a description of the study and an attached link to access the online survey (Appendix 1). A second

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reminder was sent on October 1st, 2016 and the survey was closed October 5th, 2016. Survey completion was voluntary, without any financial incentive, and anonymous.

AOSpine members who indicated that they did not wish to participate were asked to select the best reason why among the three following options: (1) I do not have a clinical practice; (2) I am not interested in the survey topic; or (3) It is inconvenient, I do not have time, I do not participate in survey, etc.

The results were summarized and reported using descriptive statistics: means and standard deviations for continuous variables and frequency counts (%) and 95% confidence intervals for categorical variables. Differences between independent proportions were assessed using Chi-square tests. Statistical significance was accepted as $p < 0.05$. Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Results

Respondent overall

Out of a total of 860 respondents, 34 (4.0%) did not wish to participate in the survey while 56 (6.5%) others indicated that they wished to participate but did not actually answer any of the survey questions. As a result, a total of 770 AOSpine members responded to our online survey, yielding a minimum response rate of 12.3% (770/6,279). Figure 1 presents the breakdown of the respondents throughout the survey.

Non-respondents

Among the 34 members who indicated that they did not wish to participate, 30 selected one of the three explanatory answers provided: *I do not have a clinical practice* (n=16; 47.0%); *It is inconvenient, I do not have time, I do not participate to survey, etc.* (n=10; 29.4%); and *I am not interested in the survey topic* (n=4; 11.8%). Four respondents (11.8%) did not select any explanatory answers.

Awareness and usage of CPG

Of the 770 respondents, 723 (93.9%) identified themselves as staff surgeons / surgical residents performing spine surgery while 47 (6.1%) did not. Overall, 659 (85.6%) were aware of the existence of CPG to help guide them in their clinical decision-making, and among those, 578 (87.7%) reported using such CPG in their clinical practice while 81 (12.3%) were not. Awareness and usage of CPGs were similar between non-surgeons (n=39; 83.0% and n=37; 78.7%, respectively) and surgeons (n=620; 85.8% and n=571; 79.0%, respectively).

Overall, 668 respondents provided the number of years for which they have been in practice: 32 (4.8%) surgical residents; 123 (18.4%) less than 5 years; 158 (23.6%) 5 to 10 years; 131 (19.6%) 11 to 15 years; 70 (10.5%) 16 to 20 years; 64 (9.6%) 21 to 25 years; and 90 (13.5%) over 25 years. Respondents were similarly aware ($\chi^2 = 0.83$, $p = 0.9913$) and using ($\chi^2 = 0.70$, $p = 0.9941$) CPGs in their clinical practice regardless of the number of years they have been in practice (Figure 2A).

The 670 respondents who provided their country of practice were from 91 countries. The greatest number of respondents was from Europe (n=219; 32.7%), followed by Latin America (n=162;

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24.2%), Asia Pacific (n=138; 20.6%), Middle East (n=67; 10.0%), North America (n=62; 9.2%), and Africa (n=22; 3.3%) (Figure 3). Although overall the respondents were similarly aware (χ^2 = 1.04, p = 0.9838) and using (χ^2 = 9.91, p = 0.0663) CPGs in their clinical practice regardless of their region of practice, respondents from Africa were the least aware of the existence of CPGs. However, 13 of the 15 respondents (86.7%) who reported being aware also reported using CPGs in their practice. In contrast, among the 52 respondents from North America who reported being aware of CPGs, only 37 (71.2%) stated using CPGs (Figure 2B).

Staff surgeons / surgical residents performing spine surgery on humans
Of 687 respondents who identified themselves as staff surgeons / surgical residents performing spine surgery, 485 were staff surgeons with at least 50% of their practice dedicated to spine surgery. These staff surgeons completed their residency in orthopedic surgery (n=240; 49.5%), neurosurgery (n=182; 37.5%) or spine surgery (n=63; 13.0%) as certain countries offer a formal spine surgery residency program distinct from the orthopedic surgery or neurosurgery residency program. Moreover, 19 (3.9%) were current spine fellows, while 327 (67.4%) completed a spine fellowship and 139 (28.7%) did not. The majority had more than five-year clinical experience (n=407; 84.6%) and worked in an academic setting (n=264; 54.4%), whereas 120 (24.7%) were in private practice and 101 (20.8%) worked in a community hospital. Again, most were from Europe (n=159; 32.9%), followed by Latin America (n=126; 26.1%), Asia Pacific (n=96; 19.9%), Middle East (n=41; 8.5%), North America (n=52; 10.8%), and Africa (n=9; 1.9%).

Clinical scenario #1: Immediately after a routine and uneventful multilevel posterior cervical decompression with instrumented fusion (lateral mass fixation) for degenerative cervical myelopathy, once the patient is extubated and awake, you realize he is unable to move his arms and legs. A thorough neurological exam revealed that the patient is ASIA grade A.

Overall, almost half of the 687 surgeons performing spine surgery (n=309; 45.0%) stated that they have experienced a major PND following a cervical procedure. Among the 353 (51.4%) surgeons who reported not having intraoperative SSEPs, tcMEPs or electromyography (EMG) monitoring available in their institution, one respondent commented that despite having access to intraoperative neuromonitoring, he/she does not use neuromonitoring for routine posterior cervical decompression with instrumented fusion. All other 334 (48.6%) surgeons reported using at least one method of neuromonitoring for routine multilevel posterior cervical decompressions with instrumented fusion. Overall, SSEPs is the most common technique (n=275; 82.3%), followed by tcMEPs (n=185; 55.4%) and EMG (n=142; 42.5%). For this case, 150 (44.9%) surgeons indicated using only one neuromonitoring method; 96 (28.7%) used SSEPs, 31 (9.3%) tcMEPs, and 23 (6.9%) EMG only. One hundred (29.9%) surgeons used a combination of two methods: 65 (19.5%) used SSEPs and tcMEPs; 30 (9.0%) SSEPs and EMG; and 5 (1.5%) tcMEPs and EMG. Finally, 84 (25.1%) surgeons used all three methods simultaneously.

Among the 687 surgeons, 7 (1.0%) selected that they would not consider an immediate return to the operating room without any preliminary investigation or intervention but failed to provide answers to all subsequent questions of the survey. Of the 680 surgeons who completed all questions related to the first clinical scenario, the majority (n=400; 58.8%) reported not feeling comfortable managing a patient who wakes up quadriplegic after an uneventful multilevel posterior cervical decompression with instrumented fusion and a total of 287 (42.2%) have a

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specific protocol regarding the use of high-dose corticosteroids in the setting of an acute PND in their hospital. While 156 (22.9%) considered an immediate return to the operating room, 524 (77.1%) surgeons preferred conducting some kind of investigation or medical intervention before contemplating a return to the operating room. Among surgeons who did not have access to neuromonitoring in their institution and those who did, a total of 85 and 71 surgeons considered an immediate return to the operating room whereas 246 and 278 preferred conducting some investigations or medical interventions, respectively. Surgeons reported being as likely to return to the operating room regardless of whether or not neuromonitoring was available in their institution ($\chi^2 = 2.74$, $p = 0.0981$).

Surgeons who did not consider an immediate return to the operating room without any preliminary investigation or medical intervention were given seven choices of possible investigations or medical interventions and were asked to check all that applied. In decreasing order, these surgeons selected: obtaining a cervical magnetic resonance imaging (MRI) (n=450; 85.9%); administrating high-dose corticosteroids (n=263; 50.2%); increasing the mean arterial pressure (MAP) with intravenous fluid replacement, blood transfusion and/or vasopressors (n=234; 44.7%); admitting the patient to the intensive care unit (ICU) for close monitoring (n=224; 42.7%); obtaining a cervical computed tomography (CT) (n=215; 41.0%); plain cervical x-rays (n=113; 21.6%); and blood tests (n=72; 13.7%). Overall, there were 82 combinations of investigation(s) and/or intervention(s) reported. The three most common combinations were: MRI only (n=70; 13.4%), MRI with high-dose steroids and increasing MAP (n=32; 6.1%), CT and MRI (n=28; 5.3%). One surgeon commented that he would use hyperbaric oxygen therapy, one would obtain a plain brain CT, one a brain CT or MRI perfusion, and two would obtain an spinal angiogram or spinal magnetic resonance angiography (MRA).

The results are very similar for the 485 staff surgeons with at least 50% of their practice dedicated to spine surgery: 108 (22.3%) considered an immediate return to the operating room and 377 (77.7%) favored conducting some kind of investigation or medical intervention before contemplating a return to the operating room. Most would also obtain a cervical MRI (n=328; 87.0%), followed by administrating high-dose corticosteroids (n=195; 51.7%), increasing the MAP (n=183; 48.5%), admitting the patient to the ICU (n=157; 41.6%), obtaining a cervical CT (n=151; 40.1%), plain cervical x-rays (n=73; 19.4%) and blood tests (n=53; 14.1%). Still a sizeable proportion of these experienced spine surgeons (n=225; 46.4%) acknowledged not feeling comfortable managing this case of PND.

Clinical scenario #2: During a thoracic posterior instrumented fusion for correction of a post-traumatic kyphosis, the intraoperative neuromonitoring shows a complete loss of lower extremities somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs), with maintenance of upper extremities SSEPs and MEPs. The insertion of the pedicle screws from T4 to T10 was uneventful and you corrected the deformity by closing a T7 pedicle subtraction osteotomy (PSO) a few minutes ago.

A total of 180 (28.1%) surgeons reported not using intraoperative neuromonitoring in their current institution and 461 surgeons did. Among those, 311 (67.4%) surgeons have experienced a significant intraoperative loss of neuromonitoring signal while 150 (33.6%) have not. However, overall, there were 635 surgeons who reported having personal experience with osteotomies and

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neuromonitoring. The majority of them would immediately check for neuromonitoring recording malfunction such as electrode displacement (n=453; 71.3%), release the correction (n=446; 70.2%) or increase the MAP (n=401, 63.1%) whereas some would improve oxygenation (n=292; 46.0%), obtain C-arm imaging (n=290; 45.7%), warm up the patient in case of hypothermia (n=283, 44.6%), give high-dose corticosteroids (n=226, 35.6%), check hemoglobin level (n=219; 34.5%), perform the Stagnara wake-up test (n=206, 32.4%), obtain an intraoperative CT (n=138; 21.7%), check glucose level (n=120; 18.9%), remove the pedicle screws (n=99; s15.6%) and administer a sodium channel blocker or another experimental drug (e.g. Riluzole) (n=21; 3.3%).

A total of 383 combinations of strategies were reported; the commonest was the immediate release of the correction with no other intervention (n=25; 3.9%). Three respondents commented to check for any actual physical compression of neural elements; other comments included to obtain a postoperative CT, expand the decompression at T7, remove the pedicle screws that showed evidence of misplacement on C-arm imaging, check with the anesthesiologist for any extra-spinal cause, infuse warm saline with papaverine, and loosen the correction, wait for the signal to return and correct the deformity after two weeks at the time of the second stage.

Provided that the neuromonitoring readings are accurate, the majority of the 641 surgeons (n=402; 62.7%) considered the immediate release of the correction to be the most important intervention to maximize neurologic recovery for this potential PND. While 28 (4.4%) indicated that they have no MAP target in cases of PND, a target MAP > 80 mmHg was the most popular (Figure 4). Although three surgeons commented that it depended on the MAP preoperatively, none provided further details. Most surgeons would discontinue their MAP target after 48h (n=179; 27.9%), followed by 24h (n=149; 23.2%), once the patient has fully recovered (n=131; 20.4%), 72h (n=128; 20.0%) and after one week (n=32; 5.0%). Two surgeons indicated five days and seven specified that they did not think increasing the MAP would help in this case. The majority of surgeons (n=392; 61.2%) reported not feeling comfortable managing a patient who had a complete loss of lower extremities SSEPs and MEPs after closing a pedicle subtraction osteotomy. Of the 485 staff surgeons with > 50% of their practice dedicated to spine surgery, 206 (42.5%) reported not feeling comfortable managing such PND.

Usefulness and likelihood of using CPGs on perioperative PND

Of 631 surgeons performing spine surgery, 572 (90.6%) believe that the creation of CPGs for the assessment and management of PND would be useful. In addition, 322 (51.0%) extremely likely and 274 (43.4%) would be likely to use this CPG in their clinical practice. At least 85% of the 485 staff surgeons with > 50% of their practice dedicated to spine surgery also reported that the creation of such CPG would be useful and over 90% would be at least likely to use it regardless of their region of practice.

Discussion

To our knowledge, this is the first study to report on the awareness and usage of CPGs among a large international clinical community. Of the 723 respondents who identified themselves as staff surgeons / surgical residents performing spine surgery on humans, 85.8% were aware of the existence of CPG and 79.0% indicated using CPGs to help guide their clinical decision-making. The awareness and usage were similar for respondents that were non-surgeons. Overall,

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respondents from 91 countries were similarly aware and using CPGs regardless of their region of practice or number of years of clinical experience.

Despite the incidence of PND reported to be relatively low, 45.0% and 67.4% of the surgeons encountered a major PND following a cervical procedure and a significant loss of neuromonitoring signal intraoperatively, respectively. For the majority of surgeons (51.4%) performing multilevel posterior cervical decompression with instrumented fusion, intraoperative neuromonitoring is not available in their institution; one surgeon commented that despite having access to intraoperative neuromonitoring, he does not use it for this type of procedure. Surgeons' responses to the first clinical scenario varied widely. While 22.9% would consider an immediate return to the operating room, the others favored conducting some preliminary investigations or interventions. Cervical MRI (85.9%), high-dose corticosteroids (50.2%), and increase of the MAP (44.7%) were the three most cited actions. Among the 82 combinations of investigation(s) and/or intervention(s) reported, MRI only (13.4%), MRI with high-dose steroids and increase MAP (6.1%), CT and MRI (5.3%) were the three commonest. Although 42.2% surgeons have a specific protocol regarding the use of high-dose corticosteroids in the setting of an acute PND in their hospital, 42 surgeons commented that they would appreciate that a CPR in the assessment and management of PND specifically address the use of corticosteroids. An important number of surgeons (58.8%), even those with at least 50% of their practice dedicated to spine surgery (46.4%), reported not feeling comfortable managing a patient who wakes up quadriplegic after an uneventful multilevel posterior cervical decompression with instrumented fusion.

The second clinical scenario yield a total of 383 combinations of management strategies with very little consistency among surgeons. The commonest strategy involved the immediate release of the correction with no other intervention, which was selected by only 25 surgeons (3.9%). However, provided that the neuromonitoring readings are accurate, the majority of surgeons (62.7%) considered the immediate release of the correction as the most important intervention to maximize neurologic recovery for this potential PND. The largest proportion of surgeons, which was only 31.1%, agreed that the MAP target should be > 80 mmHg. There was also little consensus regarding the how long the MAP target should be maintained. Again, the majority of surgeons (61.2%) and a 42.5% of staff surgeons with > 50% of their practice dedicated to spine surgery reported not feeling comfortable managing a patient who had a complete loss of lower extremities somatosensory and motor evoked potentials after closing a pedicle subtraction osteotomy. The majority of surgeons regardless of their region of practice agreed that the creation of such CPG would be useful and over 90% would be at least likely to use it.

Strengths and Limitations

The primary limitation to this study is our low response rate of 12.3%, which was conservatively calculated using the number of survey respondents (n=770) divided by the number of maximum net e-mail invitation sent (n=6,279). It is generally accepted that at least half of the target sample should complete the survey questionnaire to gain confidence in the validity of the statistics used to provide insight about to the target population, especially with regards to the response bias, i.e. the difference between responders and non-responders.[11,12] We think that our calculated response rate greatly underestimated our actual response. It is very likely that our maximal sample was much smaller than the maximum *net e-mail invitations sent* since not all members did actually receive the invitation emails. Depending of the e-mail configuration, the invitation e-

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mails might have been blocked or directed to the *spam* box by the spam filter. Some members may have changed their primary e-mail address from the time of their subscription. Many people have more than one e-mail addresses, some members might have subscribed using an e-mail address that is not their primary one. The fact that only 21.6% and 22.7% of the e-mails sent on September 21st and October 1st, respectfully, were actually opened might support the fact that our survey failed to reach a significant proportion of our target sample. Moreover, since most non-respondents declined participating in this survey because they did not have a clinical practice and less than 10% of the email invitations opened had the link to the survey clicked, it is highly possible that a good proportion of members did not participate to the survey after reading the invitation email because they lack clinical experience. Finally, the survey was only available in English, which might explain why 56 (6.5%) individuals who began the survey did not answer any of the survey questions.

Conclusions

Although response rate is important, representativeness of the survey sample is crucial.[13,14] Despite our relatively low overall response rate, we obtained insight related to the nonresponse bias and among the 687 respondents who identified themselves as staff surgeons / surgical residents performing spine surgery, 485 (70.6%) were staff surgeons with at least 50% of their practice dedicated to spine surgery. Therefore, we are confident that our survey results are representative of our targeted population.

Most clinicians worldwide appear to be aware of the existence of CPGs and to be actively using CPGs to help guide their clinical decision-making, highlighting a strong global positive attitude toward CPGs. Although the incidence of PND is relatively low, almost half of the surgeons stated that they have experienced a major PND following a cervical procedure, and over two-thirds of surgeons using neuromonitoring have encountered a significant intraoperative loss of neuromonitoring signals. Furthermore, despite considerable training and experience, most surgeons performing spine surgeries reported not feeling comfortable managing PND. Also, there was a large variability in the number and combinations of strategies used to manage PND, and thus little overall consensus among surgeons. Finally, since the great majority of surgeons highly value the creation CPGs for the assessment and management of PND in adult spine surgery and are at least likely to use this CPG in their clinical practice, we believe that developing this CPG would fill a gap and have a significant beneficial impact in the field of adult spine surgery on a global level.

Acknowledgment

AOSpine is a clinical division of the AO Foundation—an independent medically guided nonprofit organization.

The AOSpine Knowledge Forums are pathology focused working groups acting on behalf of AOSpine in their domain of scientific expertise. Each forum consists of a steering committee of up to 10 international spine experts who meet on a regular basis to discuss research, assess the best evidence for current practices, and formulate clinical trials to advance spine care worldwide. Study support is provided directly through AOSpine's Research department.

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Figure legends

Figure 1: Respondents' breakdown

Figure 2: Proportion of respondents that reported (i) being awareness of the existence of clinical practice guideline(s) to guide decision-making and (ii) using such guidelines in clinical practice according to (A) the numbers of years of practice (n=668) and (B) the region of practice (n=670)

Figure 3: Geographic distribution of survey respondents. Color legend: yellow: North America; red: Latin America; blue: Europe; pink: Middle East; gray: Africa; green: Asia Pacific. The white flags represent the number of respondents from each country. Any country in Europe with 5 participants or less was colored but not flagged: Belgium, Greece, Poland, Romania (n=5); Denmark, Finland, Hungary, Ukraine (n=4); France, Israel, Norway, Slovenia (n=3); Czech Republic, Lithuania (n=2); Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Latvia, Macedonia, Moldova (n=1). Hong Kong (n=4), Singapore (n=4), Palestinian West Bank and Gaza (n=1), Qatar (n=1) and Rwanda (n=1) are not shown on this map

Figure 4: Mean arterial pressure target reported by surgeons performing spine surgery to manage perioperative neurologic deficit (n=641)

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Table 1: Details on the distribution and access to the online survey

E-mail Invitation to Participate	Net e-mail invitation sent to members	Link to survey clicked	Number of respondents
September 21st, 2016	6,191	547	770
Reminder: October 1st, 2016	6,279	696	

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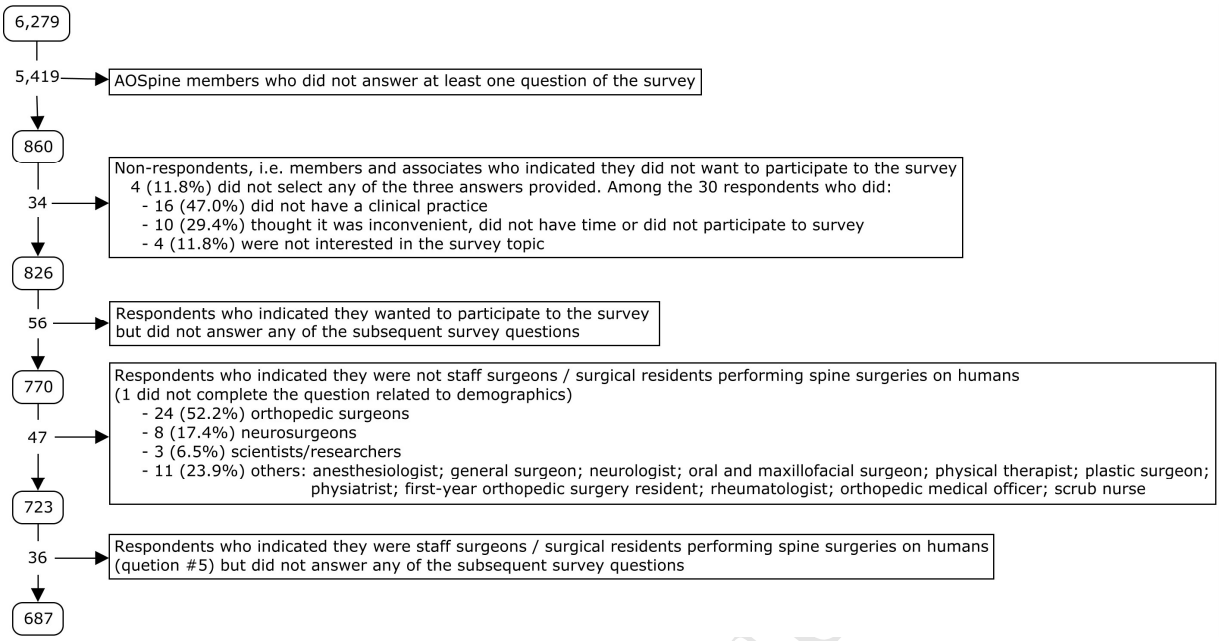

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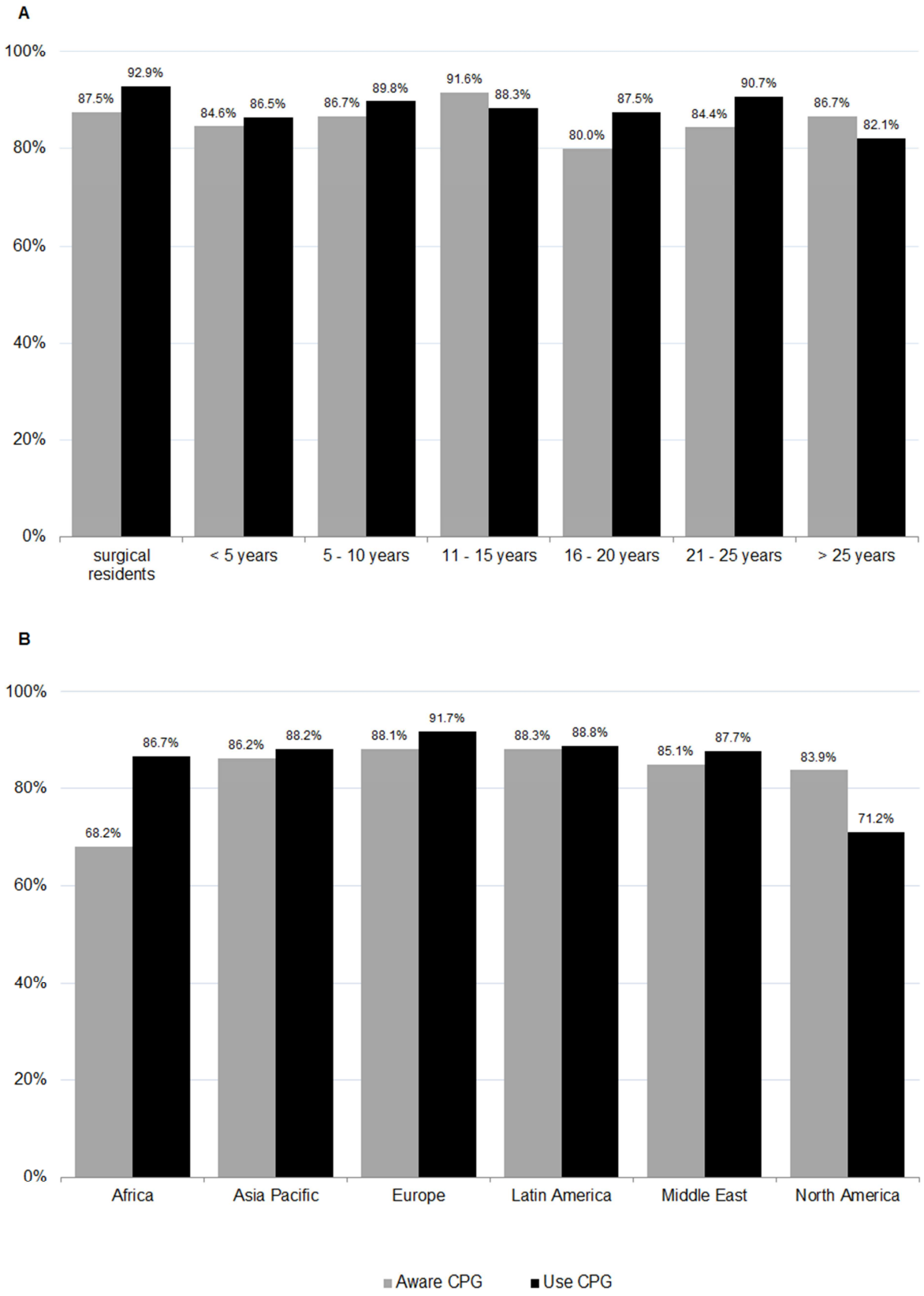
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5 - 10 years
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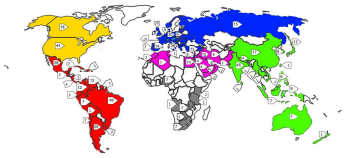

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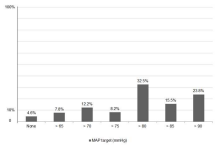

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HIGHLIGHTS

- We aimed to assess how spine surgeons deal with perioperative neurological deficit
- 85.6% of respondents reported being aware of clinical practice guideline(s)
- 87.7% acknowledged using these guidelines
- Most surgeons performing spine surgery reported not feeling comfortable managing PND
- 90.6% of surgeons believed that CPGs for the management of PND would be useful

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The authors declare no conflicts of interest. Dr. Fehlings wishes to disclose consulting agreements with Zimmer Biomet, InVivo Therapeutics and Pfizer.

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Abbreviations list

AAOS	American Academy of Orthopedic Surgeons
ASIA	American Spinal Injury Association
CPG	Clinical practice guideline
CT	Computed tomography
DCM	Degenerative cervical myelopathy
ICU	Intensive care unit
LEMS	Lower extremity motor scores
MAP	Mean arterial pressure
MRA	Magnetic resonance angiography
MRI	Magnetic resonance imaging
OPLL	Ossification of the posterior longitudinal ligament
PND	Perioperative neurologic deficits
SRS	Scoliosis Research Society
SSEPs	Somatosensory evoked potentials
tcMEPs	Transcranial motor evoked potentials
EMG	Electromyography

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