Cost effectiveness of multimodal intraoperative monitoring during spine surgery

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Introduction

Debates on the cost-effectiveness of multimodal intraoperative monitoring (IOM) have been going on for more than a decade [5, 7, 10, 11, 18].

One of the prejudices against the effectiveness of IOM was the idea that monitoring techniques can merely document neurological injury, with very little space for intervention. This concept should nowadays be abandoned because, in most of the circumstances, an experienced intraoperative neurophysiologist detects an impending injury to the nervous system in time for corrective measures to be taken. This ultimately results in either complete prevention or limitation of a neurological deficit. There is increasing evidence and general consensus among experts that IOM is valuable in spinal cord monitoring. From case reports to clinical series, authors from different centres worldwide have documented the benefit of IOM to prevent irreversible neurological injury [13, 15]. Yet, in the era of evidence based medicine, we are more and more asked to demonstrate that monitoring “really makes a difference” by performing control studies.

However, existing data on the benefit of monitoring are limited to Class IV (most studies based on retrospectively collected data) and Class III (clinical studies with

prospective data collection, retrospective studies with clearly reliable data) studies. On the other hand, Class I and II studies (prospective randomized trials) are very unlikely to occur because of both ethical and medico-legal constraints. To design a randomized controlled study would imply to assign some patients to a designated control group where IOM is not used. Those supporting the use of IOM would refuse to randomize patients for such a study because the likelihood of deficit prevention is so high—with currently used IOM techniques—that a controlled study would not be acceptable to most patients and surgeons.

Moreover, the adequate sample of patients to design randomized studies far exceeds the case load of a single institution. For example, the power calculations for a prospective randomized trial of evoked potential monitoring for reduction of paraplegia following spine surgery is such that as many as 4,674 patients would be necessary to prove that IOM reduces the incidence of neurological deficit of 50% (from 1 to 0.5%). Similarly, the number of patients for a prospective randomized trial aimed to prove that motor evoked potential (MEP) monitoring is superior to somatosensory evoked potential (SEP) monitoring (remaining incidence of severe injury from 0.5 to 0.1%) is about 2,934 patients per group [8].

It therefore appears that today it is still valid what Phillips and Park observed in 1990 [14], when they stated that “advocates of most monitoring techniques point to the lack of bad outcomes as proof that their particular technique has value”. From here, one feasible path to increase the evidence of the benefit of IOM is that of performing historical control studies or meta-analyses. Meanwhile, the value of IOM should be proved also from a merely economical perspective, in terms of cost-effectiveness.

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In this short report, we reviewed some recent data on the rate of neurological complications after different kind of spine and spinal cord surgery. We then analyzed the costs of health care for spinal cord injured patients and, finally, compared these costs with those of IOM.

Neurological complications after spine and spinal cord surgeries

In 1975, a review by MacEwen et al. [9] over 7,000 spine surgeries revealed an incidence of neurologic complications of less than 1%. Some economic considerations appear in the article by Daube who, in 1989 [4], reported the experience of the Mayo Clinic in the use of SEPs during orthopaedic spine surgery. SEPs were used in 351 patients. In 11 patients SEP remained unchanged in spite of post-operative neurological deficits. SEP changes occurred in seven patients; in two of them SEP recovered spontaneously during surgery, in other two patients changes were irreversible and in three recovered after the surgical strategy was modified. IOM was therefore of benefit in 1% (3 of 351) of the patients.

More recently, large reviews on the risk of injury related to spine surgery were reported by the Scoliosis Research Society (SRS). In 1991 SRS reported an incidence of neurological deficit after all forms of spinal surgery around 1.6% [6]. In 1995 in a large multicenter survey by the SRS on 51,263 patients undergoing major spine surgeries, Nuer et al. [13] reported a rate of paraparesis/paraplegia of 0.55% considering false-negative (postoperative neurologic deficits in spite of unchanged SEPs: 0.127%) and true-positive (postoperative neurologic deficits predicted but not—or only partially—prevented by intraoperative SEP changes: 0.423%) results.

The SRS [17] reported that in 2005 the incidence of neurological deficits after surgery for scoliosis was about 1.2% (0.1% complete cord, 0.4% incomplete cord, 0.7% nerve root) with an higher rate for congenital and degenerative scoliosis (2.1%).

Considering spinal surgeries other than surgery for scoliosis, the reported rate of neurological complications after anterior cervical discectomy and fusion is about 0.3% of patients [1]. Persistent voice changes caused by excessive traction on the recurrent laryngeal nerve are reported in 1% of the cases [16].

Costs of health care for spinal cord injury

Health care costs for patients with neurological deficits and other medical complications secondary to spinal cord lesions are assessed mainly in the field of traumatic spinal

cord injury. For a representative person in 1988, the life-time cost of living with complete paraplegia after injury at age 33 years was estimated to be 500,000 USD. For a complete quadriplegia incurred at age 27 years, the cost rose to 1 million USD [3].

About 18 years later, in 2006, according to the National Spinal Cord Injury Statistical Center (Birmingham, AL, USA) [12], the average yearly health care and living expenses and the estimated lifetime costs that are directly attributable to spinal cord injury vary greatly according to the severity of injury as it follows. For a high tetraplegia (C1–C4) first year average expenses are 741,425 USD, for a low tetraplegia (C5–C8) are 478,782 USD and for a paraplegia are 270,913 USD. For the same injury severity, eastimated lifetime costs at the age of 25 year are 2,924,513 USD, 1,653,607 USD and 977,142 USD, respectively. Therefore, transferring this data to the field of spinal surgery for scoliosis, considering an incidence of paraplegia of 0.1%, the use of IOM is cost effective if 977,142 USD cover the costs of monitoring 1,000 surgical procedures. This means an average of 977 USD/case. In the case of tetraplegia, IOM would be cost-effective if the cost of a single monitoring procedure does not exceed 2,924 (high level tetraplegia) or 1,653 (low level tetraplegia).

Costs of IOM

If we consider that in 1995 Nuwer et al. [13] estimated that the cost for monitoring scoliosis surgery with SEPs in the United States was approximately USD 600, the costs associated to paraplegia clearly outweigh the costs of performing IOM. In the aforementioned study by Daube [4], the cost of performing SEP monitoring in all 351 patients was estimated at less than 200,000 USD, which was far less of the potential health care costs for the three patients where SEP monitoring prevented a paraplegia/quadruplegia.

Calculations on the real costs of an IOM procedure are difficult to assess because these should consider the costs of personell (neurophysiology technician, neurophysiologist), IOM device, and disposable materials. Nevertheless, reports from different field in IOM, exceeding the field of spinal cord monitoring, consistently support its cost-effectiveness [2, 18, 19].

With regards to spinal cord monitoring, it should be consider that nowadays, after the introduction of MEPs, the reliability of IOM is further increased and there has not been a single report in the literature of postoperative paraplegia in spite of intraoperatively preserved MEPs. This strongly supports the combined use of SEPs and MEPs during spine and spinal cord surgery.

One aspect that is usually not considered when estimating the costs of postoperative permanent neurological morbidity is human suffering. This is difficult to evaluate in economic terms but should be taken into account when assessing the cost-effectiveness of IOM. One possibility to obtain a socioeconomic estimation of human suffering is to use the economic compensation that is awarded to patients by a court of law in the cases of accidents or malpractice that lead to similar neurological condition (for example paraplegia). As pointed out by Moller [11], if this amount of money is taken into consideration, the estimated economic gain from the use of IOM may become enormous.

Conclusion

Multimodal intraoperative monitoring can only reduce the likelihood of neurological complications during spine and spinal cord surgery. The rate of these complications remains very low. Still, considering the enormous costs of health care and the human suffering related to a severe injury to the spinal cord that results in paraplegia/paraparesis or quadriplegia/quadruparesis, there is enough evidence to prove that costs of performing IOM surely do not exceed those of health care for the injured patients.

Conflict of interest statement None of the authors has any potential conflict of interest.

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