Spine Deformity
www.spine-deformity.org

Spine Deformity 5 (2017) 117−123

Prognosis of Significant Intraoperative Neurophysiologic Monitoring Events in Severe Spinal Deformity Surgery

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Received 26 May 2015; revised 22 November 2016; accepted 26 November 2016

Abstract

Background: Intraoperative neurophysiologic monitoring has become a standard tool for mitigating neurologic injury during spinal deformity surgery. Significant monitoring changes during deformity correction are relatively uncommon. This study characterizes precipitating factors for neurologic injury and relates significant events and postoperative neurologic prognosis.

Methods: All spinal deformity surgeries at a West African hospital over a 12-month period were reviewed. Patients were included if complete operative reports, monitoring data, and postoperative neurologic examinations were available for review. Surgical and systemic triggers of monitoring events were recorded and neurologic status was followed for 6 weeks postoperatively.

Results: Eighty-eight patients met inclusion criteria. The average age was 14 years (3−28). The average kyphosis was 108° (54°−176°) and average scoliosis was 100° (48°−177°). There were 44 separate neurologic events in 34 patients (39%). The most common triggers were traction or positioning (16), posterior column osteotomies/vertebral column resections (9/1), and distraction, corrective maneuvers, or implant placement (12). On surgery completion, 100% (12/12) of events from non-osteotomy-related surgical procedures, 75% (12/16) of events from traction or positioning resolved; however, 0% (0/10) of events from osteotomies resolved completely. Eight percent (7/88) had new neurologic deficits postoperatively, all with intraoperative monitoring changes. In 6 of these 7 patients, the event was attributed to an osteotomy; in 1 patient the cause was not determined. At 6-week follow-up, all patients had some preserved motor function bilaterally with the ability to walk (ASIA D/E) or recovered completely.

Conclusions: Intraoperative signal changes were most frequently from traction or positioning. However, the most common cause of persistent neurologic deterioration and the only cause of postoperative neurologic deficit was the performance of osteotomies. Unlike traction- or instrument-related correction, osteotomies produce irreversible changes, from canal intrusion or sudden localized deformity change. The incidence of postoperative neurologic deficit is very low when the inciting cause is reversed; however, osteotomy-related events are irreversible, with a high incidence of associated lasting neurologic injury.

Keywords: Spinal deformity; Intraoperative neurophysiologic monitoring; Complications; Nerve injury; Spinal cord injury

Introduction

Neurologic injury is an uncommon but potentially devastating complication after correction of severe spine deformities [1]; the overall incidence of major neurologic injury is 0.4% to 1.9% [2,3]. Intraoperative neurophysiologic monitoring (IONM) can provide the surgeon with reliable early warning that spinal cord injury has occurred or is impending [4]. When both somatosensory evoked potentials (SSEPs) and motor evoked potentials (MEPs) [5-9] are used together, the sensitivity for detection of permanent neurologic injury during spinal deformity surgery is 99.6% to 100% [8,10,11].

Author disclosures: BTB (none); DMZ (none); VMN (none); RGE (none); HJK (reports personal fees from Zimmerbiomet, personal fees from K2M, outside the submitted work); OB-A (none). None of the authors received payments or services, either directly or indirectly (ie, via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work.

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http://dx.doi.org/10.1016/j.jspd.2016.11.002

SSEPs directly assess dorsal column function. For SSEP monitoring during spinal surgery, afferent sensory conduction in the dorsal columns serves as a surrogate for global cord function. Neurologic deficits [12], including paraplegia [13,14], can occur despite normal SSEPs. The largest multicenter study found SSEP monitoring alone to have a false-negative rate of 0.063% [15]. For that reason, a combined IONM approach to include motor monitoring is widely used.

MEPs directly monitor the function of the anterior and central portions of the spinal cord, including all corticospinal pathways. They are very sensitive indicators of corticospinal tract injury, and have proven to be very sensitive indicators of spinal cord ischemia during spinal deformity correction [16,17]. Compared with SSEPs, they are also more sensitive to hypotension, hypothermia, and general anesthesia, especially inhalation anesthetics [18-21].

Because of both the devastating consequence and the cost of spinal cord injury and paraplegia, IONM has proven to be an important and cost-effective [22-24] adjunct to spinal deformity surgery. Reliable IONM [25] has largely obviated the need for the Stagnara wake-up test, and has replaced it at many centers [26,27]. Experienced neuromonitoring teams have been shown to have fewer than one-half as many neurologic deficits compared to teams with relatively little experience [15].

Largely because of the inherent high sensitivity of neurophysiologic monitoring to systemic and anesthetic factors, false-positive and negative events are commonplace during spinal deformity surgery. Several algorithms have been proposed to resolve these false-positives and negatives [28,29]. However, to our knowledge, no algorithms have been proposed that differentiate among *surgical* causes of IONM changes. To our knowledge, this is the first study to correlate intraoperative triggering events and IONM changes to postoperative deficits in severe spinal deformity surgery, and to propose an interventional algorithm that differentiates between reversible and irreversible surgical injury.

Methods

A prospectively collected database of consecutive spinal deformity operations at a single site in Ghana, Africa, over a 12-month period was reviewed. Intraoperative traction was used to facilitate correction. The amount of traction used was determined by the surgeon's discretion, and decreased as needed if monitoring changes were noted. Skull traction was applied by attaching weights to a halo or Gardner-Wells tongs once the patient was positioned (Fig. 1). Traction was applied to patients' lower extremities by attaching weights to specially designed foot/ankle boots (Fig. 2) that maintained function throughout the course of the procedure. If monitoring changes were noted, weights were removed from the head and/or feet until monitoring returned to baseline.

Fig. 1. Traction setup with previous halo fixation.

Anesthetic protocol

Anesthesia was maintained using total intravenous anesthesia (TIVA), using only propofol and fentanyl. Infusion rates were adjusted in response to surgical, hemodynamic, and neurophysiological monitoring cues. All Infusions were discontinued at the conclusion of the procedures. Neuromuscular blocking agents were not administered after induction and intubation. Blood pressure, body

Fig. 2. Lower-extremity traction through specially designed boots.