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Clinical Study

Frequent neuromonitoring loss during the completion of vertebral column resections in severe spinal deformity surgery

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Abstract

BACKGROUND CONTEXT: Intraoperative monitoring (IOM) is an essential method for preventing postoperative spinal deficits during posterior vertebral column resection (VCR) surgery for treatment of severe spine deformities, but the IOM features directing at VCR procedures are rarely reported and need to be further clarified.

PURPOSE: To evaluate an important surgical point that will lead to the IOM loss frequently, and then remind the surgeons to pay close attention to impending monitoring changes during posterior VCR surgery.

STUDY DESIGN/SETTING: Retrospective study.

PATIENT SAMPLE: A total of 77 patients with severe spine deformities who underwent posterior VCR and deformity correction surgeries from January 2012 to May 2015 are retrospectively analyzed in our spine center.

OUTCOME MEASURES: IOM (motor-evoked potentials [MEP] and somatosensory-evoked potentials) was used for intraoperative spinal function assessment.

METHODS: Patients were divided into 2 groups according to their preoperative spinal function, including 27 patients with preoperative spinal deficits and 50 patients with spinal normal. And the IOM data during surgery, especially among VCR procedures, were mainly analyzed in the present study.

RESULTS: With the VCR procedure almost complete, most patients showed varying degrees of IOM loss that included 37 cases showing obvious IOM degenerations and 21 cases showing significant IOM loss with alerts immediately. Moreover, the patients with preoperative spinal deficits have more significant decreasing percentage in MEP amplitude (81% *vs.* 68%, $p<.05$) than those patients without.

CONCLUSIONS: With the VCR procedure almost complete, surgeons must pay closely attention to the IOM signals and should be ready to take corresponding surgical measures to deal with the impeding monitoring loss.

Keywords: Intraoperative monitoring (IOM) loss; MEP; Preoperative spinal deficits; Spine deformity; SSEP; VCR completion; Vertebral column resections (VCR)

Introduction

Posterior vertebral column resection (VCR) has become a useful technique for treatment of severe and rigid spine deformities; meanwhile, it is one of biggest spinal surgeries and at higher risk of excessive blood loss and neurological deficits [1]. The neurological complications remain a major worry for us and can result from direct neural injury during VCR or deformity correction. Fortunately, intraoperative monitoring (IOM) leads to a decreased rate of postoperative paralysis, and has proven its value as a predictor of neurologic outcome in spine deformity surgery [2,3]. According to our data and clinical experience, VCR surgery is most likely to result in IOM loss compared with other surgical methods. Until now, there are a few reports concerning further analyzing the features of IOM loss during VCR procedure for deformity correction surgery. Therefore, to help surgeons and to monitor the preparation of the impending IOM changes during VCR procedures, our objective is to clarify a surgical point that may frequently lead to IOM signals loss.

FDA device/drug status: Not applicable.

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Patients and methods

Patients

We retrospectively collected 77 patients with severe spine deformity who underwent posterior VCR and deformity correction surgeries from January 2012 to May 2015 in our spine center. Patients were monitored by combining somatosensory-evoked potentials (SSEP) and motor-evoked potentials (MEP), and it would be considered as effective IOM when we recorded reliable MEP or SSEP.

The detailed IOM data (the amplitude of MEP and SSEP) and its corresponding surgical procedures were collected prospectively. To further distinguish the difference of IOM loss, all 77 patients were divided into 2 groups according to their preoperative spinal function as follows: (1) 27 patients with preoperative spinal deficits and (2) 50 patients without.

Postoperative neurological function assessment

Early and long-term postoperative neurologic outcomes were assessed for the following functions: motor, sensory, and pain at immediate postoperative and 1-year postoperation in this cases series.

IOM recording

Motor-evoked potentials and SSEP baseline was performed after unfolding the vertebral lamina using subcutaneous needle electrodes (Axon Systems Inc., Hauppauge, NY, USA). MEP parameters are as follows: 250 to 500 V constant voltage, 6–7 pulses, 200–400 μs duration, 2.5–4.0 ms stimulus interval, C3–C4 cortex regions for stimulation electrodes, the abductor hallucis muscles and the first dorsal interosseous muscles (control) for recording. Meanwhile, SSEP parameters are the following: 15 to 30 mA constant current over posterior tibial nerve, single pulse, 5.1 and 5.7 Hz frequency, 200–300 μs duration, Cz and Fpz for lower extremities cortical SSEP recording, 30–300 Hz bandpass filter, 100 millisecond (ms) window, average after 200 stimulations.

IOM criteria

In the present study, the IOM loss includes 2 implications: on one hand, the obvious IOM degenerations that have not yet reached warning criteria are defined as 40%–80% MEP loss or 30%–50% SSEP drop associated with high-risk surgical maneuvers; on the other hand, the significant IOM loss with monitoring alerts is defined as rapid, more than 80% MEP or 50% SSEP loss associated with high-risk surgical maneuvers. Others are thought of as unchanged IOM.

Anesthesia methods

General anesthesia was induced with a bolus dose of propofol (3 mg/kg) and fentanyl (2.5 ug/kg) combined with a short-acting muscle relaxant and inhalation agents (sevoflurane or nitrous oxide). No muscle relaxants or inhalation agents were given after induction and intubation. Subsequently, maintenance of anesthesia was propofol (5–8 mg/kg/h) based on hemodynamic response; remifentanyl (0.1 ug/kg/min); and a total dose of 5–6 ug/kg fentanyl (intermittent infusion) was used during the whole operation.

Statistical analysis

Statistical comparisons were made by one-way analysis of variance using SPSS 19.0 (SPSS, Inc., Chicago, IL, USA) software, and $p<.05$ was considered statistically significant.

Results

The Table shows the patients' diagnosis and general data. Fig. 1 presents the IOM results. There are 37 (48.1%) cases showing obvious IOM degenerations and 21 (27.3%) cases showing significant IOM loss with monitoring alerts. Nineteen (24.7%) cases showed no obvious IOM changes. With the VCR procedure almost complete, the IOM signals, especially MEP, often drop obviously (Fig. 2, Left). According to our analysis, the increasing stretching force in spinal cord (Fig. 2, Right) is probably the major reason for this IOM loss. In addition, the MEP is probably more sensitive to detect the change of spinal stretching force than SSEP monitoring (Fig. 2).

Furthermore, among the 77 patients with VCR surgeries, there are 27 cases with preoperative spinal deficits and 50 cases without (Fig. 3, Left). The muscle strength distributions in the 27 patients with spinal deficits are shown in Fig. 3, Middle. Moreover, during the procedure of VCR completion, the patients with preoperative spinal deficits have more significant decreasing percent in IOM amplitude (81% *vs.* 68%, $p<.05$) than those patients without (Fig. 3, Right). In addition, the postoperative neurologic outcomes show that the incidence of new spinal deficits is 10.4% (8/77) at immediate

Table
Diagnosis and general data

	Patients (n=77)
Diagnosis	**No. (%)**
Congenital scoliosis	27 (35.1)
Congenital kyphoscoliosis	37 (48.1)
Tuberculous kyphoscoliosis	8 (10.4)
Adult scoliosis	2 (2.6)
Neuromuscular scoliosis	1 (1.3)
Neurofibromatosis scoliosis	1 (1.3)
Ankylosing spondylitis kyphosis	1 (1.3)
General data	**Mean±SD (range)**
Male: female	34:33
Age	19.7±14.6 (2–60 years)
Height	143.7±22.7 (88–179 cm)
Weight	45.6±18.6 (13–97 kg)
BMI	21.3±5.5 (14.1–44.5)
Operation time	197.8±39.8 (150–380 min)
Bleeding volume	2349.2±674.6 (800–4900 ml)
Osteotomy type	PVCR

BMI, body mass index; PVCR, posterior vertebral column resection.