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CASE REPORT

The value of bilateral ipsilateral and contralateral motor evoked potential monitoring in scoliosis surgery

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Abstract Intraoperative monitoring (IOM) of the motor pathways is a routine procedure for ensuring integrity of corticospinal tracts during scoliosis surgery. We have previously demonstrated presence of ipsilateral motor evoked potentials (MEPs) during IOM for scoliosis surgery, but its significance was uncertain. In this case series, we show concurrent ipsilateral and contralateral MEP amplitude changes obtained with cortical stimulation are of value in reducing false positive observations during IOM. The use of this easily recordable MEP is thus advocated as a diagnostic adjunct to contralateral MEPs for scoliosis and spinal surgery.

Keywords Intaoperative monitoring · Scoliosis · Motor evoked potential · Contralateral · Ipsilateral · Cortical stimulation

Introduction

Intraoperative monitoring (IOM) of the motor pathways is a routine procedure for ensuring integrity of corticospinal tracts during scoliosis surgery. In combination with somatosensory evoked potentials, motor evoked potentials (MEPs) monitoring is widely utilized in operations with significant risks of spinal cord damage [4].

We have previously demonstrated presence of ipsilateral MEPs during IOM for scoliosis surgery, but its significance was uncertain [5]. In this paper, we would like to further address this novel and important issue.

In IOM, MEPs are elicited mostly with contralateral cortical electrical stimulation. Ipsilateral MEP responses have not been adequately studied in this context. In a previous study, we have shown that ipsilateral MEPs of equivalent or larger amplitudes than contralateral MEPs were readily elicited during IOM of scoliosis surgery [5]. The lack of significant ipsilateral and contralateral latency differences suggests that bilateral motor cortex stimulation has resulted in ipsilateral MEPs, which may have comprised early ipsilaterally conducted corticoreticulospinal [2] or corticopropriospinal components, and late transcallosally stimulated corticospinal components [1]. This might also explain the larger amplitudes of ipsilateral MEPs obtained than MEPs derived from contralateral motor cortex stimulation.

While the relative contributions of ipsilaterally and transcallosal conducted MEPs remain uncertain, they may together provide additional information regarding the integrity of descending motor tracts. In this study, we present our experience on this aspect.

Methods

Over a 1-year period, IOM was performed for 25 patients with idiopathic scoliosis. All were asymptomatic, neurologically normal and underwent correction for thoracic

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level scoliosis. Of these, nine cases had significant MEP changes intraoperatively (see Table 1 for a summary). Apart from case 5, all underwent total intravenous anesthesia (TIVA), maintained with propofol infusion.

Cortical stimulation alternated with monitoring of somatosensory evoked potentials obtained from posterior tibial nerve stimulation. Stimulating electrodes consisted of 9 mm gold-plated disc electrodes at C3C4 (International 10–20 system) affixed with collodion. C3 was the active stimulating electrode position for left cortical stimulation, while C4 was for right cortical stimulation. Stimulation output was increased from 50 mA in steps of 5 mA until a reproducible MEP was elicited. The intensity was then increased and fixed at 10% above this threshold intensity to obtain a supramaximal MEP response. MEP recordings were obtained with 13 mm disposable subdermal needles (Technomed Europe, Beek, Netherlands) in the first dorsal interossei (FDI) (for upper limb recordings) and tibialis anterior (TA) (for lower limb recordings) bilaterally. Filter settings were set at 10 Hz and 2 kHz. Input impedance of stimulating and recording electrodes were maintained below 5 kΩ.

For induction of anesthesia, sodium thiopentone at 4 mg/kg and fentanyl at 2 mcg/kg was administered. 0.8 mg/kg of intravenous atracurium was used to facilitate endotracheal intubation. No further doses of neuromuscular blocking agents were used subsequently. For TIVA, anesthesia was maintained using the regime of 10 mg/kg of propofol for the first 10 min, 8 mg/kg for the nest 10 min and 5 mg/kg for the subsequent length of operation. Fifty percent of air in oxygen was administered. Morphine was titrated as required for pain relief. Monitoring included electrocardiography, pulse oximetry, capnography and direct radial artery pressures. All patients were kept nornothermic with a warming blanket. Normotensive anesthesia was maintained throughout the operation.

After approximately 45 min post-induction, a train of 4-twitch assessment was performed using a nerve stimulator (Fischer Paykel NS242, UK). Cortical stimulation was commenced only when the amplitude of the fourth was visibly similar to the first. An interval of 3–5 min was allowed between two trains of cortical stimulation. This alternated with monitoring of somatosensory evoked potentials from posterior tibial nerve stimulation.

Motor evoked potentials (MEPs) from the FDI and TA muscles were recorded bilaterally from the upper and lower limbs. Peak to peak amplitudes (between two largest peaks opposite in polarity) and onset latency was measured for MEP responses in each limb, obtained from ipsilateral and contralateral cortical stimulation. Hence, ipsilateral MEPs refer to MEPs recorded from the TA on the same side as cortical stimulation. For each patient, ten consecutive supramaximal MEPs obtained before insertion of pedicle screws was averaged to obtain the two parameters as a baseline. During insertion of pedicle screws and instrumentation, a 50% reduction of the MEP amplitude or 10% prolongation of latency was brought to the surgeon's attention.

Results

Cases 1–3 (group I) showed significant reduction in ipsilateral and contralateral MEP amplitudes in both lower limbs intraoperatively. This was evident from right and left cortical stimulation. Wake-up test was performed 15 min after reversal of anesthesia. All three patients had unilateral or bilateral absent of leg movements, necessitating removal

Table 1 Summary of data of all nine cases

Motor evoked potential amplitude												
Case	Age	Sex	R stim		L stim		R stim		L stim		Anesthesia	Wake up test	Outcome
			I UL	C UL	I UL	C UL	I LL	C LL	I LL	C LL			
1	12	F	NC	↓	NC	↓	↓	↓	↓	↓	TIVA	Abnormal	N after I
2	15	F	↓	↓	NC	NC	↓	↓	↓	↓	TIVA	Abnormal	N after I
3	15	F	NC	NC	NC	NC	↓	↓	↓	↓	TIVA	Abnormal	N after I
4	14	F	NC	NC	NC	NC	NC	NC	NC	↓	TIVA	N	N
5	14	F	NC	NC	NC	NC	NC	↓	NC	↓	Sevoflurane	N	N
6	19	F	NC	NC	NC	NC	NC	NC	NC	↓	TIVA	N	N
7	14	F	NC	NC	NC	NC	↓	NC	NC	NC	TIVA	N	N
8	15	F	NC	NC	NC	NC	↓	NC	↓	NC	TIVA	N	N
9	19	F	NC	NC	↓	NC	NC	NC	↓	NC	TIVA	N	N

F female, *R* right, *L* left, *I* ipsilateral, *C* contralateral, *UL* upper limb, *LL* lower limb, *Stim* cortical stimulation, *TIVA* total intravenous anesthesia, *NC* no change; ↓ reduced, *N* normal, *I* implant correction

and readjustments of implants. The MEPs returned to baseline amplitudes subsequently.

Cases 4–6 (group II) showed significant reduction only in the contralateral lower limb MEP amplitudes from cortical stimulation. Wake-up tests performed similarly were normal. The MEPs returned to baseline amplitudes subsequently.

In contrast, cases 7–9 (group III) showed significant reduction only in the ipsilateral MEP amplitudes from cortical stimulation. Wake-up tests were again normal in this group. The MEPs returned to baseline amplitudes subsequently as well.

No significant changes were noted in the MEP latencies and somatosensory evoked potentials in all nine patients.

There were no post-operative neurological deficits in all these patients, and in all 25 patients monitored over this 1-year period.

Discussion

The present findings show that ipsilateral and contralateral MEP amplitude changes together were highly suggestive of neurological dysfunction during IOM, as seen in group I, and confirmed with wake-up tests. In contrast, group II and III changes did not result in neurological dysfunction, although intraoperatively, the surgical team was alerted and wake-up tests performed. It also validated the higher sensitivity of MEPs in comparison with SSEPs, as previously reported (Hilbrand et al. [3]).

What are the possible explanations for these observations? It is known that up to 30% of motor tracts descend ipsilaterally in some individuals [8]. As mentioned in our previous study [5], the lack of significant ipsilateral and contralateral latency differences suggests that bilateral motor cortex stimulation has resulted in ipsilateral MEPs, which may have comprised early ipsilaterally conducted corticoreticulospinal [2] or corticopropriospinal components, and late transcallosally stimulated corticospinal components [1]. Mechanical compromise of these tracts, in addition to contralaterally descending motor tracts, suggest a critically large functional derangement enough to result in visible neurological deficits. Conversely, sole reduction of ipsilateral or contralateral MEP amplitudes may not have resulted in a significantly severe dysfunction of the motor tracts to cause visible neurological deficit. Based on intraoperative wake-up tests, these cases can be classified as false positives. Assuming that cord dysfunction was not the cause, vascular, mechanical and anesthetic factors [6] cannot be excluded in these instances.

It should be mentioned that none of the nine patients exhibited features of horizontal gaze palsy or signs suggestive of the autosomal recessive horizontal gaze palsy with progressive scoliosis syndrome, which can be associated with abnormalities of pyramidal decussation [7]. All patients were neurologically normal, and thus, ipsilateral MEPs observed cannot be attributed to this condition.

While we feel that any change above 50% in MEP amplitude (rather than complete disappearance) warrant alertation of the surgical team by erring on the side of caution, this may occasionally result in false positive outcomes. However, concurrent ipsilateral and contralateral MEP amplitude changes point to a definite surgical urgency. In this situation, ipsilateral MEPs are of value in reducing false positive observations during IOM. The use of this easily recordable MEP is thus advocated as a diagnostic adjunct to contralateral MEPs for scoliosis and spinal surgery.

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

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