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Effects of partial neuromuscular blockade on lateral spread response monitoring during microvascular decompression surgery ☆

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HIGHLIGHTS

- The efficacy of partial neuromuscular blockade (NMB) for intraoperative monitoring of lateral spread responses (LSRs) has not been established yet.
- The successful intraoperative LSR monitoring can be achieved under partial NMB with train-of-four and T1 amplitude monitoring.
- The spontaneous free-run facial EMG occurred less frequently in patients with partial NMB.

ABSTRACT

Objective: We evaluated the effect of partial neuromuscular blockade (NMB) and no NMB on successful intraoperative monitoring of the lateral spread response (LSR) during microvascular decompression (MVD) surgery.
Methods: Patients were randomly allocated into one of three groups: the TOF group, the NMB was targeted to maintain two counts of train-of-four (TOF); the T1 group, maintain the T1/Tc (T1: amplitude of first twitch, Tc: amplitude of baseline twitch) ratio at 50%; and the N group, no relaxants after tracheal intubation. Successful LSR monitoring was defined as effective baseline establishment and maintenance of the LSR until dural opening.
Results: The success rate of LSR monitoring was significantly lower in the TOF group. But, there was no significant difference between T1 and N. The detection rate of spontaneous free-run electromyography (EMG) activity was significantly higher in the N group compared with the TOF and T1 groups.
Conclusions: Partial NMB with a target of T1/Tc ratio at 50% allows good recording of LSR with same outcome as surgery without NMB, and reduced spontaneous EMG activity.
Significance: We suggested the availability of partial NMB for intraoperative LSR monitoring.

1. Introduction

Hyperactive dysfunction of facial nerves can cause a hemifacial spasm (HFS), which is characterized by chronic and involuntary contraction of the ipsilateral portion of the face (Miller and Miller, 2012; Sindou, 2005; Yamashita et al., 2005). Spontaneous recovery from an HFS is very rare; moreover, HFSs can lead to serious aesthetic and functional disabilities (Neves et al., 2009).

Primary HFSs are generally related to vascular compression of the facial nerve at the root exit zone (Miller and Miller, 2012; Sindou, 2005). Several treatment options for primary HFSs have

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been proposed. Oral medications, such as anticonvulsants, are sometimes prescribed for mild HFSs. However, the use of these medications is often hindered by their poor effectiveness and possible side effects (Miller and Miller, 2012). Another option is to administer injections of botulinum toxin, which achieves temporary treatment; however, this effect generally persists for only 3–4 months (Costa et al., 2005; Miller and Miller, 2012; Wang et al., 2013). The only known curative treatment to date is microvascular decompression (MVD) surgery (Miller and Miller, 2012; Sindou, 2005).

Hyperexcitable facial nerves can cause an abnormal muscle response known as the lateral spread response (LSR) in patients with a primary HFS (Fernandez-Conejero et al., 2012; Sindou, 2005; Yamashita et al., 2005). The LSR can be detected by electromyography (EMG) monitoring of the facial muscles upon stimulation of another branch of facial nerves (Fernandez-Conejero et al., 2012; Moller and Jannetta, 1985b; Sindou, 2005). Møller and Jannetta reported that the LSR disappears immediately upon removal of the offending vessels and if it remains at the end of operation, the spasms are more likely to persist after surgical procedure (Moller and Jannetta, 1985a,b, 1987). Accordingly, intraoperative LSR monitoring is considered to be an effective diagnostic tool for complete decompression and also to be an important prognostic factor for MVD surgery (Kong et al., 2007; Sekula et al., 2009; Yamashita et al., 2005).

Anesthetic drugs, especially neuromuscular blocking agents, can significantly influence the success of EMG monitoring (Kizilay et al., 2003; Sloan, 2013). Previous studies have recommended the avoidance of neuromuscular blockade (NMB) during intraoperative electrophysiologic monitoring (IOM) (Kim et al., 2013; Kothbauer, 2007). However, some neurosurgeons feel uncomfortable about avoiding NMB, considering the risks of patient movement during surgery and/or patient movement by transcranial stimulation. In some cases, large doses of anesthetics are needed for complete immobility; such doses can cause hemodynamic instability in some patients (Cai et al., 2009; Kizilay et al., 2003). Several pieces of evidence support the idea that successful IOM can be conducted under partial NMB and patient immobility (Kizilay et al., 2003; Lennon et al., 1992; Sloan, 2013). For example, previous studies have reported successful EMG monitoring of facial nerves in otologic surgeries (Cai et al., 2009; Ho et al., 1989; Kizilay et al., 2003; Lennon et al., 1992; Sloan, 2013); additional studies have found that facial muscles have a lower sensitivity to NMB compared with other muscle types (Abdulatif and el-Sanabary, 1997; Rimaniol et al., 1996). Furthermore, spontaneous tonic contraction of facial muscles in patients with a high tonic grade (Lee et al., 2012) can prevent LSR monitoring; thus, partial NMB could be beneficial to these patients. Therefore, LSR monitoring during MVD surgery may be possible with partial NMB, and LSR monitoring under partial NMB may be preferable to LSR monitoring in some patients. However, no clinical studies have yet compared the success of LSR monitoring under partial NMB with that under NMB, or compared the effectiveness of different degrees of partial NMB for LSR monitoring. Therefore, the current study was designed to compare two different degrees of partial NMB, in addition to the absence of NMB, on the success of LSR monitoring in MVD surgery.

2. Methods

This prospective, randomized, controlled study was approved by the Hospital Institutional Review Board. This study is registered at the www.clinicaltrials.gov website, under protocol number NCT01598961, May 2012.

One hundred fifty patients who were diagnosed with an HFS and who underwent MVD surgery with intraoperative LSR monitoring between May 2012 and February 2013 were enrolled in this study (Fig. 1). Patient age at the times of surgery ranged from 20 to 70 years. Patients with renal diseases, neuromuscular diseases, and American Society of Anesthesiologists (ASA) physical status class III or more were excluded from this study.

After obtaining written informed consent from each patient, patients were randomly allocated into one of three groups, in a 1:1:1 allocation ratio. Randomization was conducted using random numbers generated by internet based computer program (www.randomizer.org). It created 1 set of 150 non-unique numbers ranging from 1 to 3 (matched up 1 with TOF group, 2 with T1 group, and 3 with N group, respectively). All attending neurophysiologists and surgeons were blinded to the study group assignments of the patients. All surgical procedures were performed by the same neurosurgeon (K. Park).

2.1. Anesthesia and research protocol

General anesthesia was induced and maintained with propofol and remifentanil. Using supramaximal stimuli, the baseline T1 amplitude (Tc) was established using a neuromuscular transmission module (M-NMT module, Datex-Ohmeda Inc., Helsinki, Finland) (Dahaba et al., 2002). This module measures the response of the adductor pollicis brevis muscle, using train-of-four (TOF) stimulation of the ulnar nerve, and visually displays the associated TOF count, ratio, and T1/Tc value (Fig. 2). Rocuronium (0.6 mg/kg) was infused to facilitate tracheal intubation. Propofol and remifentanil were continuously infused through a target controlled infusion (TCI) pump (Orchestra™, Fresenius Vial, France). Propofol (3–5.5 μg/ml) was adjusted to maintain a BIS level of 40–60. Remifentanil (1–4 ng/ml) was titrated to control patient arterial blood pressure within a 20% range of its preoperative value.

Subjects were randomly allocated to one of three groups. In the TOF group, NMB was targeted to maintain two counts of TOF during the LSR monitoring. In the T1 group, NMB was targeted to maintain a T1/Tc ratio of 50% during the LSR monitoring (Fig. 2). In the N group, no additional NMB drugs were used after tracheal intubation. In the TOF and T1 groups, an intravenous vecuronium continuous infusion (0.5 μg/kg/min) was initiated when the appropriate NMB target was reached after tracheal intubation. During surgery, the TOF response of the adductor pollicis brevis muscle was monitored every 5 min with the NMT module; the vecuronium dose was also adjusted every 5 min to maintain the appropriate NMB target.

The primary endpoint of this study was the incidence of successful LSR monitoring. We assessed the success of LSR detection at six time points: (1) before skin incision (baseline), (2) before dural opening, (3) after dural opening, (4) before decompression, (5) after decompression, and (6) after dural closure. In some patients, the LSR would disappear with dural opening or after drainage of the cerebrospinal fluid (CSF) before decompression (Kim et al., 2010). Accordingly, the success of LSR monitoring was defined as the successful detection and establishment of the baseline LSR, and the maintenance of this LSR before dural opening or decompression. Failure to detect the LSR before dural opening (time points 1 and 2) was regarded as a monitoring failure. Reduction of the EMG amplitude by greater than 50% of the baseline as reported by the neurophysiologist, without a surgical reason, was also considered to be a monitoring failure.

The secondary outcome variables of this study included the incidence of spontaneous patient movements during EMG monitoring, the incidence of spontaneous free-run EMG activity, the mean doses of propofol–remifentanil, and the mean BIS level. The doses of propofol–remifentanil and BIS levels were recorded