CASE REPORT

Reversal of moderate and intense neuromuscular block induced by rocuronium with low doses of sugammadex for intraoperative facial nerve monitoring

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Abstract We report two cases in which moderate and intense rocuronium-induced neuromuscular block was reversed intraoperatively with low sugammadex doses in order to facilitate electromyographic evaluation of facial nerve function during surgery of the parotid gland and the middle ear. Acceleromyography was used to assess reversal of neuromuscular block before starting electromyography monitoring. Rocuronium-induced neuromuscular block was reversed with sugammadex 0.22 mg·kg⁻¹ when the TOF ratio was 0.14 in the first patient, and with sugammadex 2 mg·kg⁻¹ during intense block (PTC 0) in the second patient. In each case, appropriate neuromuscular function (TOF ratio ≥ 0.9) was established soon after sugammadex administration, and electromyographic evaluation of facial nerve was successfully conducted. The use of rocuronium and sugammadex, coupled with objective neuromuscular monitoring with acceleromyography, assured complete restoration of neuromuscular function and created the optimal conditions for the surgical team.

PALABRAS CLAVE Monitorización neuromuscular; Rocuronio; Sugammadex; Monitorización intraoperatoria del nervio facial

Reversión del bloqueo neuromuscular moderado e intenso inducido por rocuronio con dosis bajas de sugammadex para monitorización intraoperatoria del nervio facial

Resumen Presentamos 2 casos con bloqueo neuromuscular superficial e intenso inducidos por rocuronio y revertidos intraoperatoriamente con dosis bajas de sugammadex para facilitar la evaluación de la función del nervio facial mediante electromiografía durante la cirugía de la glándula parótida y oído. La aceleromiografía se utilizó para poder valorar el grado de bloqueo neuromuscular antes del comienzo de la electromiografía y para titular la dosis baja apropiada.

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del antagonista. El bloqueo neuromuscular se revirtió con sugammadex 0,22 mg·kg⁻¹ para un ratio del tren de 4 (TOFr) de 0,14 en el primer paciente y con sugammadex 2 mg·kg⁻¹ durante un bloqueo intenso (PTC 0) en el segundo paciente. La recuperación completa de la función neuromuscular (TOFr ≥ 0,9) se alcanzó después de la administración de sugammadex en ambos casos.

La evaluación mediante electromiografía del nervio facial se realizó con éxito después de la reversión con sugammadex. El uso de rocuronio y de sugammadex a dosis bajas, asociado con monitorización objetiva por medio de aceleromiografía, aseguró el restablecimiento completo de la función neuromuscular y permitió condiciones óptimas de trabajo para el equipo quirúrgico.

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Introduction

Intraoperative facial nerve monitoring (IFNM) with evoked electromyography (EEMG) is a method used for assessing the anatomic and functional integrity of nerves during surgical procedures in which the risk of nerve injury is high, such as total parotidectomy and chronic inflammatory conditions.¹ Potential benefits of IFNM are numerous, and include the ability to identify the facial nerve (decreasing trauma) and reduce surgical time. Based on the available evidence, IFNM can now be considered an established standard of care in such procedures. While this technique requires intact neuromuscular transmission, patient immobility needs to be preserved throughout surgery. Neuromuscular blocking agents (NMBA) can nonetheless be included as part of the anesthetic technique, along with objective monitoring of the degree of neuromuscular block, so that complete restoration of neuromuscular transmission can be assured before IFNM.²,³

We report two cases in which NMBA were administered and later antagonized with low doses of sugammadex for intraoperative monitoring with acceleromyography (AMG) and EEMG for IFNM.

Materials and methods

The anesthetic management and neuromuscular monitoring for both reported cases were conducted in the same way. Upon arrival to the operating room, standard monitoring began, including continuous electrocardiogram, pulse oximetry, and non-invasive arterial blood pressure. Atropine 0.5 mg and midazolam 1 mg were administered intravenously. Following ~3 min of oxygen supplementation via facemask, anesthesia was induced and maintained using a target-controlled infusion (TCI) of propofol (4–5 μg·ml⁻¹) and remifentanil (3–4 ng·m⁻¹), titrated to maintain the State Entropy between 40 and 60. To reduce pain from propofol administration, the patients previously received 0.5 mg·kg⁻¹ of lidocaine intravenously. The lungs were ventilated with oxygen and air (FiO₂ 0.4) using pressure-controlled mode with a peak pressure of 13 mmHg. Ventilation parameters were adjusted to maintain an end-tidal CO₂ between 40 and 45 mmHg.

Neuromuscular monitoring

After loss of consciousness, neuromuscular monitoring with AMG (TOF Watch SX monitor, Organon Ireland Ltd., MSD, Swords, Co., Dublin, Ireland) was conducted in accordance with the Good Clinical Research Practice guidelines.⁴ The forearm and fingers (except the thumb) were immobilized and train-of-four (TOF) stimulation delivered every 15 s to the ulnar nerve. Core and skin temperature were measured and maintained above 35 °C (nasopharynx) and 32 °C (hand), respectively. The CAL2 mode of the AMG monitor was used, which automatically calibrates the response and detects supramaximal current. Signal stabilization was confirmed (i.e. <5% variation during TOF for at least 2 min). Data were automatically downloaded to a personal computer using dedicated software.

Case report 1

A 30-year-old female patient, ASA I (57 kg, BMI 22.54 kg·m⁻²), Mallampati class I and with no history of gastroesophageal reflux, was scheduled for tympanoplasty. After induction of anesthesia and calibration of the neuromuscular monitoring, rocuronium 35 mg (0.6 mg·kg⁻¹) was administered. A TOF ratio of zero was obtained in 2 min 45 s, and a size 4 ProSeal laryngeal Mask Airway was inserted. During the period of surgical dissection, four additional maintenance doses of rocuronium (0.1–0.15 mg·kg⁻¹) were administered when the TOF count returned to 2. Two hours after induction of anesthesia and before IFNM began, sugammadex 13 mg (0.22 mg·kg⁻¹) was administered. The TOF ratio (TOFr) recovered from 0.14 to 0.9 in 5 min (Fig. 1A).

Case report 2

A 57-year-old male patient, ASA II (80 kg, BMI 27.68 kg·m⁻²), Mallampati class II was scheduled for parotidectomy. The patient was under bisoprolol treatment for arterial hypertension. Following induction of anesthesia and AMG calibration, rocuronium 50 mg (0.6 mg·kg⁻¹) was administered. After 1 min 45 s no response to TOF stimulation could be observed, and a 7 mm ID endotracheal tube was inserted with the aid of an Airtraq laryngoscope. Less than 15 min
Reversal of moderate and intense neuromuscular block induced by rocuronium

![Graph showing TOF ratio](Image)

**Figure 1** (A) Intraoperative reversal of moderate rocuronium-induced neuromuscular block. The TOF ratio increased from 0.14 to 0.9 five minutes after the administration of sugammadex 0.22 mg kg⁻¹. Vertical lines represent T1 and superimposed red dots represent TOF ratio and (B) intraoperative reversal of intense rocuronium-induced neuromuscular block. A TOF ratio of 0.9 was achieved 6 min after the administration of sugammadex 2 mg kg⁻¹. A post-tetanic count of zero was recorded at the time of sugammadex administration. Vertical lines represent T1 and superimposed red dots represent TOF ratio.

after rocuronium administration, and when the PTC was 0, neuromuscular block was reversed with sugammadex 160 mg (2 mg kg⁻¹). The TOF ratio reached 0.9 after 6 min 15 s (Fig. 1B).

Both patients received morphine (5 and 7 mg IV, respectively) 60 min before the end of operation, and recovered uneventfully from general anesthesia. Written consent for publication was granted by the patients.

**Discussion**

We report two cases in which low doses of sugammadex were administered at variable degrees of neuromuscular block. The reversal agent was administered intraoperatively so that IFNM could be performed without any deficits in neuromuscular transmission.

Historically, anesthesia for procedures requiring IFNM has been provided without the use of NMBA, due to the concern that may it affect the results of EMG monitoring. Avoidance of neuromuscular blockade, however, can increase the risks and difficulties associated with tracheal intubation and potentially result in movement during critical phases of the surgical procedure. In the cases we report, the inclusion of neuromuscular block was advantageous; surgical relaxation was maintained for close to 2 h during dissection in the first patient, and facilitated orotracheal intubation in the second subject.
Before the introduction of sugammadex into clinical practice, neuromuscular block was routinely antagonized with neostigmine. Nonetheless, neostigmine may present several limitations for the management of cases like the ones described here; antagonism of intense blockade, such as in the second case we report, may be inefficient after neostigmine administration, which may in turn prolong surgical time. Even when administered at a TOF count of 2, the time to complete recovery was 16 min. In our cases, low dosage of sugammadex, along with AMG monitoring, restored neuromuscular function and allowed for IFNM to be conducted. Complete recovery from neuromuscular block was achieved only 6 min 15 s after sugammadex administration.

It is unclear whether complete restoration of neuromuscular function is imperative for IFNM. It has been suggested that since facial muscles are more resistant to neuromuscular block than adductor pollicis (AP), IFNM can be successful despite 50–75% twitch depression. Nonetheless, in a study reported by Adamus et al., EMG responses to nerve stimulation during spinal surgery could not be elicited until the TOF ratio at the AP was >0.9. We chose to completely reverse neuromuscular block in order to ensure that residual blockade would not interfere with IFNM.

In the cases we report, sugammadex dosage was seemingly lower than the one conventionally used. Schaller et al. had previously shown that, when administered at a TOF ratio of 0.5, sugammadex 0.22 mg·kg⁻¹ can restore neuromuscular function in an average time of 2 min, and sugammadex 0.08 mg·kg⁻¹ can restore it in an average of 5 min. Sugammadex 2 mg·kg⁻¹ was also successfully used to reverse profound block (PTC 1–2) in ~5 min. The use of low doses of sugammadex produced smooth recovery of neuromuscular function in each patient. Adequate restoration of neuromuscular function (TOF ratio > 0.9) was assessed with AMG, thus decreasing any potential risk of incomplete recovery that could appear with low doses of the antagonist.

The availability of rocuronium and sugammadex allows for the provision of profound neuromuscular block during intubation and surgery, and complete recovery when intraoperative EMG monitoring is needed. Objective monitoring with AMG was vital in order to assure complete restoration of neuromuscular function.

Conflicts of interest

Joaquín Fabregat López has received speakers’ fees from MSD.

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