Case Report

# Sugammadex to reverse neuromuscular blockade and provide optimal conditions for motor-evoked potential monitoring


**ABSTRACT**

Sugammadex is a novel pharmacologic agent, which reverses neuromuscular blockade (NMB) via a mechanism that differs completely from acetylcholinesterase inhibitors. By encapsulating rocuronium, sugammadex can provide recovery of neuromuscular function even when there is a profound degree of NMB. We report anecdotal experience with the use of sugammadex to reverse NMB to facilitate intraoperative neurophysiological monitoring (motor evoked potentials) in an adolescent with scoliosis during posterior spinal fusion. Its potential application in this unique clinical scenario is discussed, and potential dosing schemes are reviewed.



**Key words:** Motor-evoked potentials; neuromuscular blockade; posterior spinal fusion; sugammadex


## Introduction

Posterior spinal fusion (PSF) remains the primary surgical intervention for the correction of scoliosis. To decrease the incidence of inadvertent spinal cord injury and resultant neurological deficits, the current standard of care includes intraoperative neurophysiological monitoring with somatosensory-evoked potential and motor-evoked potentials (MEPs).[1,2] Although the incidence of neurologic deficits following surgical procedures on the vertebral column may be as high as 3.7%–6.9% without neurophysiological monitoring, this can be decreased to <1% with neurological monitoring.[2] However, to provide the optimal conditions for effective neurophysiological monitoring, the anesthetic technique must be modified. In general, a total intravenous (IV) anesthesia with propofol and opioid is frequently the technique of choice.[3,4] When MEP monitoring is used, neuromuscular blockade (NMB) must be minimal, preferably absent, or at a constant level.[5]

Sugammadex (Bridion®, Merck and Co, Whitehouse Station, New Jersey, USA) is a novel pharmacologic agent, which was approved for clinical use in December 2015 by the United States Food and Drug Administration. It reverses NMB with a mechanism that differs completely from acetylcholinesterase inhibitors by encapsulating rocuronium or vecuronium and thereby may provide complete recovery even when there is a profound degree of NMB.[6-11] We report anecdotal experience with the use of sugammadex to reverse NMB to facilitate MEP monitoring during PSF. Its potential application in this unique clinical scenario is discussed, and previous reports of its use in the pediatric population are reviewed.


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## Case Report

The Institutional Review Board approval is not required for isolated care reports at Nationwide Children's Hospital. A 12-year-old, 56 kg adolescent with idiopathic scoliosis presented for anesthetic care during PSF (T4–L4 levels). Associated comorbid conditions included learning disability, hyperopia, and attention deficit hyperactivity disorder. Home medications included melatonin, risperidone, dextroamphetamine, and citalopram. The patient had no other comorbidities and no prior anesthetic exposure. Preoperative hemoglobin level and hematocrit were 12.7 g/dL and 37.9%, respectively. On the day of surgery, the child was held nil *per os* for 8 h. She was transported to the operating room (OR), and the standard American Society of Anesthesiologists' monitors were placed. A peripheral IV cannula was placed after achieving analgesia with 70% nitrous oxide in oxygen. Anesthesia was induced with propofol (3 mg/kg) and fentanyl (2 μg/kg). NMB was provided by rocuronium (0.9 mg/kg). The trachea was intubated with a size 7.0 mm ID cuffed endotracheal tube. NMB monitoring was performed using a peripheral nerve stimulator (SunStim™ Plus, SunMED (Medline Industries, Inc. Mundelein, Illinois, USA)) over the ulnar nerve at the wrist. An arterial cannula and a second peripheral IV cannula were placed. Anesthesia was maintained with desflurane titrated to maintain the bispectral index at 50–60, and a sufentanil infusion (0.2–0.4 μg/kg/h) was used to maintain analgesia. The patient was turned prone in preparation for the surgical procedure. Evoked potential monitoring included multimodality monitoring with median somatosensory and posterior tibial somatosensory recordings, transcranial electrical motor stimulation, and free-run and stimulated electromyography. Monitoring was initiated just before the beginning of surgery, 75 min after the administration of rocuronium. However, motor-evoked responses were not observed in any of the muscles, and no twitch was noted on train-of-four (TOF) monitoring, demonstrating persistent NMB. No change was noted despite multiple neuromuscular response checks by the neurological monitoring team over the next 15 min. A repeat check using the peripheral nerve stimulator at this time revealed one weak twitch to TOF stimulation. After discussion with the surgical and neurological monitoring teams, a decision was made to reverse the NMB. Sugammadex (16 mg/kg) was administered, and within 1 min, there was a full return of neuromuscular function, confirmed by four strong and equal responses to TOF stimulation through the peripheral nerve stimulator. MEP monitoring also revealed strong responses from bilateral brachioradialis, vastus lateralis, tibialis anterior, and abductor hallucis brevis muscles. After recording the baseline neuromuscular and sensory responses, surgery was started and the procedure was completed successfully without any complication. At the end of surgery, the patient's trachea was extubated in the OR, and the postoperative neurological examination was found to be satisfactory.

## Discussion

To provide optimal conditions for intraoperative neurophysiological monitoring, specific modifications of the anesthetic technique are required such as limiting the degree of NMB to obtain a baseline neuromuscular monitoring status, before the commencement of surgery. Although endotracheal intubation can be accomplished without the use of NMB agents (NMBAs) or the duration of blockade shortened by decreasing the dose of rocuronium (0.3 mg/kg), we used 0.9 mg/kg of rocuronium to facilitate an ideal endotracheal intubation condition with the assumption that neuromuscular recovery would be satisfactory within the time taken to establish more vascular lines, placement of a urinary catheter, preparation of the patient for neuromuscular monitoring, and positioning of the patient in a prone position.[12,13] However, in our patient, NMB was profound even after 90 min after the administration of rocuronium (0.9 mg/kg). Although rocuronium is considered an intermediate-acting NMBA, its metabolism and elimination can vary significantly from one patient to another. Furthermore, at higher doses, the duration of action can frequently be prolonged.[12] High-dose rocuronium (1.2 mg/kg or 3–4 times the $ED_{95}$), which is frequently administered to facilitate rapid sequence endotracheal intubation, may prolong the duration of blockade up to 50%–300% when compared with normal doses (1–2 $ED_{95}$). As we were unable to obtain baseline ME, the decision was taken to not proceed with surgery without obtaining a baseline reading, given the need to monitor spinal cord function during the procedure.

To date, there are limited data regarding the use of sugammadex in the pediatric-aged patient with a limited number of prospective trials.[14] Unlike neostigmine, which increases the concentration of acetylcholine at the neuromuscular junction by inhibiting acetylcholinesterase to reestablish muscular transmission, sugammadex reverses the NMB by forming a very tight water-soluble complex with rocuronium in the plasma. This promotes a diffusion of rocuronium molecules from the neuromuscular junction to the plasma and effectively frees up the acetylcholine receptors at the neuromuscular junction.[15,16]

Anecdotal use of sugammadex has been reported for the reversal of NMB in difficult clinical scenarios such as children with neuromuscular diseases including myasthenia

gravis, Duchenne muscular dystrophy, and other myopathic conditions.[17-19] We report for the first time the administration of sugammadex to provide rapid reversal of profound NMB to allow for MEP monitoring during spinal surgery. In our patient, the administration of sugammadex (16 mg/kg) led to the rapid and complete reversal of NMB, allowing the initiation of neurophysiological monitoring and surgery without further delay. Although we used the largest recommended dose of sugammadex (16 mg/kg), this dose is generally recommended only for the rapid reversal of NMB after the administration of an intubating dose of rocuronium (1.2 mg/kg) or when there are no signs of impending neuromuscular recovery. Dosing is based on the TOF response with 2 mg/kg recommended when there are ≥2 twitches of the TOF and 4 mg/kg if there are 1–2 posttetanic twitches. As such, it is likely that a lower dose (4 mg/kg) would have been effective as our patient had 1 weak twitch in response to TOF monitoring.

The reported adverse effect profile with sugammadex has generally included minor and self-limited issues including nausea, vomiting, pain, hypotension, and headache. Severe adverse effects during the preclinical trial included bradycardia and anaphylaxis. As noted in the package inserted, marked bradycardia with the occasional progression to cardiac arrest has been observed within minutes after administration. No mechanism has been postulated for this response. In preclinical trials, anaphylaxis occurred in 0.3% of healthy volunteers, requiring treatment with only an H1-antagonist such as diphenhydramine. However, in a comprehensive literature review of anaphylactoid reactions following sugammadex, 15 cases of hypersensitivity following sugammadex administration were noted.[20] We did not notice any untoward side effect or complication in our patient. With such caveats in mind, we believe that sugammadex is a useful agent in various clinical scenarios including the one that we have outlined where rapid reversal of profound NMB is clinically indicated.

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### Conflicts of interest
There are no conflicts of interest.

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