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Case Report

Anaesthesia Section

Sugammadex: Breaking Through Residual Paralysis after Neostigmine's Limits

APARNA BAGLE[1], SANIA RODRIGUES[2]

ABSTRACT

Persistent neuromuscular blockade following the use of Neuromuscular Blocking Agents (NMBAs) remains a significant postoperative concern, often resulting in delayed recovery and prolonged stays in the Post- Anaesthesia Care Unit (PACU). It occurs when the effects of NMBAs are not fully reversed before emergence from anaesthesia, leading to complications such as hypoxaemia, impaired airway reflexes, aspiration, and respiratory failure. Despite the use of traditional anticholinesterase reversal agents, incomplete recovery of neuromuscular function can still occur due to factors such as improper dosing of reversal agents, variability in patient response to NMBAs, and the lack of adequate neuromuscular monitoring during surgery. These challenges pose risks for patients and highlight the need for effective management strategies. This report describes two cases of residual neuromuscular blockade that persisted despite the administration of anticholinesterase agents. Both patients experienced delayed recovery of muscle strength in the immediate postoperative period, raising concerns about inadequate blockade reversal. In both cases, the administration of sugammadex, a novel selective relaxant-binding agent, led to rapid and complete resolution of the neuromuscular blockade. These cases emphasise the efficacy of sugammadex in addressing persistent neuromuscular blockade, particularly in situations where traditional reversal agents fail to achieve full recovery.

Keywords: Anaesthesia recovery period, Cholinesterase inhibitors, Muscle relaxation, Paralysis, Postoperative complications, Reversal agents

CASE REPORT

Case 1

A 29-year-old man, weighing 35 kg with no known medical conditions, was scheduled for ileostomy reversal surgery three weeks after undergoing two separate surgeries for ileal perforation, performedf two weeks apart. Preoperative labs showed Haemoglobin (Hb) 11.5 g/dL, platelets 403,000/µL, total protein 7.5 g/dL, albumin 3 g/dL, with an albumin/globulin ratio of 0.63, and normal electrolytes, renal, and liver function tests. He had significant muscle wasting due to a 30 kg weight loss postsurgery. Intravenous (i.v.) access was established, and standard anaesthesia monitoring was initiated. Following i.v. premedication with glycopyrrolate 0.2 mg and midazolam 1 mg, anaesthesia was induced with propofol 80 mg, fentanyl 75 mcg, and vecuronium 4 mg bolus. Anaesthesia was maintained with isoflurane, then switched to sevoflurane an hour before skin closure. A total of 10 mg vecuronium was administered in 1 mg increments every 30-40 minutes. The surgery lasted 180 minutes without complications. Reversal was attempted with neostigmine 0.05 mg/kg and glycopyrrolate 0.008 mg/kg after 60 minutes following the last vecuronium dose. Due to inadequate respiratory effort, an additional 0.5 mg neostigmine and 0.2 mg glycopyrrolate were given, and the patient was extubated. Five minutes later, he struggled to maintain oxygen saturation despite 100% oxygen via face mask, necessitating intermittent positive pressure ventilation with an I-Gel size 4. Suspecting residual neuromuscular blockade, 70 mg sugammadex was administered at a dose of 2 mg/kg, as the last dose of muscle relaxant had been given approximately 70 minutes prior. The patient showed significant improvement in muscle strength, head lift, and tidal volumes. The I-Gel was removed, and he maintained 98% saturation with oxygen at 5 L/min via facemask before being transferred to the PACU.

Case 2

A 76-year-old woman, weighing 65 kg and with no significant medical history, was scheduled for Open Reduction and Internal Fixation (ORIF) with plating of a proximal humeral shaft fracture under general anaesthesia, two days after sustaining the injury from a domestic fall. Peripheral i.v. access was secured, and standard anaesthesia monitors were attached. Premedication was administered with midazolam 1 mg and glycopyrrolate 0.2 mg, followed by induction of anaesthesia using fentanyl 100 mcg, propofol 140 mg and 6 mg vecuronium. Incremental doses of 1 mg vecuronium were administered, totalling 10 mg, for a procedure that lasted 190 minutes. After confirming spontaneous respiratory efforts, reversal of neuromuscular blockade was achieved with neostigmine at a dose of 0.05 mg/kg and glycopyrrolate at 0.008 mg/kg. The patient was subsequently extubated and transferred to the PACU in stable condition. Fifteen minutes after arriving in the PACU, the patient became restless, and a drop in oxygen saturation to 90% was observed. However, there were no clinical signs suggestive of laryngospasm, such as stridor or airway obstruction. Ventilation was assisted using a Bain circuit and face mask with 100% oxygen. Midazolam 2 mg and hydrocortisone 100 mg were administered. After ruling out other causes of desaturation, sugammadex 130 mg (2 mg/kg) was administered in accordance with guidelines for reversing moderate blockade, as the last dose of muscle relaxant had been given approximately 45 minutes earlier. This resulted in a significant improvement in respiration and tidal volumes. The patient regained spontaneous breathing and consciousness, while maintaining 100% saturation on 5 litres of oxygen via face mask.

DISCUSSION

Residual neuromuscular blockade occurs in approximately 33% to 64% of patients, demonstrating insufficient neuromuscular recovery upon PACU admission [1]. The incidence of persistent neuromuscular blockade varies between 4% and 50%, depending on diagnostic criteria, the type of NMBD used, reversal agents, and neuromuscular monitoring. It remains a serious concern due to its association with muscle weakness, oxygen desaturation, pulmonary collapse, and acute respiratory failure, which can lead to severe brain damage or death [2]. Murphy GS et al., reported that even mild residual paralysis

(TOF ratio <0.9) can impair pharyngeal function and airway protection [1], while Baillard C et al., associated it with critical respiratory events in the early postoperative period [3].

Residual paralysis following reversal can result from various factors. One significant cause is the administration of high doses of NMBAs, which might have occurred in our case scenarios, or prolonged duration of NMBA infusion during surgery [4]. Moreover, renal or hepatic dysfunction can impede the metabolism and elimination of NMBAs and their reversal agents, leading to prolonged effects. Inadequate dosing or administration methods, especially with conventional anticholinesterases like neostigmine, may result in incomplete reversal and persistent blockade, further exacerbated by medications such as magnesium sulphate, calcium channel blockers, and aminoglycoside antibiotics, which augment the effects of NMBAs and impede their reversal [2,4,5].

Various reversal agents, such as neostigmine and sugammadex, are available, each with its own pharmacokinetic and pharmacodynamic profiles. Sugammadex, a selective relaxant-binding agent, offers a rapid and reliable reversal of steroidal NMBAs, providing a more predictable recovery compared to traditional anticholinesterases like neostigmine [6,7]. Sugammadex binds to free steroidal NMBA in plasma at a 1:1 ratio, rapidly reducing plasma concentration and shifting the NMBA due to the concentration gradient, with its dosage depending on the depth of muscle blockade [8].

Similar to our cases, Baysal A et al., Menezes CC et al., and Answine J also employed sugammadex as a 'rescue' agent for residual paralysis after attempted reversal with neostigmine [5,8,9]. According to Blobner M et al., sugammadex was more effective than neostigmine in reversing steroidal neuromuscular blockers [10].

To improve the precision of NMBA assessment and ensure optimal reversal, quantitative neuromuscular monitoring devices, such as Train-of-Four (TOF) stimulation, can be employed [11,12]. Fuchs-Buder T et al., and Thomsen JLD et al., demonstrated that quantitative neuromuscular monitoring has proven more effective than qualitative methods in reducing residual paralysis and improving recovery outcome [13,14]. Traditionally, a TOF ratio below 0.7 indicated inadequate neuromuscular recovery, but recent data suggest that a TOF ratio above 0.9 is necessary for optimal patient safety. This is because pharyngeal dysfunction, increased aspiration risk, impaired inspiratory flow, and partial airway obstruction occur at TOF ratios below 0.9, making this ratio the new "gold standard" for neuromuscular recovery [1,7].

A thorough understanding of the causes of persistent blockade, vigilant monitoring and correct dosing of reversal agents is crucial for preventing complications and ensuring smooth recovery, underscoring the importance of evidence-based guidelines and personalised patient care.

CONCLUSION(S)

In conclusion, persistent residual neuromuscular blockade remains a significant clinical concern, with potential risks ranging from mild muscle weakness to life-threatening complications such as respiratory failure and brain damage. The incidence of residual blockade is influenced by factors such as the type of NMBA used, reversal agent efficacy, and patient-specific variables like renal or hepatic function. While traditional agents like neostigmine may offer partial reversal, sugammadex provides a more reliable and rapid solution for steroidal neuromuscular blockers, especially in cases of incomplete reversal. Quantitative neuromuscular monitoring, particularly the use of the TOF ratio, has emerged as a valuable tool in assessing neuromuscular recovery and ensuring patient safety. Given the challenges associated with residual blockade, proper dosing of reversal agents, along with vigilant monitoring, is critical to achieving optimal recovery and preventing postoperative complications. Evidence-based guidelines and tailored patient care are essential for minimising the risk of persistent neuromuscular blockade and ensuring successful postoperative outcomes.

REFERENCES

[1] Murphy GS, Szokol JW, Marymont JH, Greenberg SB, Avram MJ, Vender JS. Residual neuromuscular blockade and critical respiratory events in the postanaesthesia care unit. Anaesth Analg. 2008;107(1):130-37. Doi: 10.1213/ane.0b013e31816d1268.

[2] Plaud B, Debaene B, Donati F, Marty J. Residual paralysis after emergence from anaesthesia. Anaesthesiology. 2010;112(5):1013-22. Doi: 10.1097/ALN.0b013e3181cded07.

[3] Baillard C, Gehan G, Reboul-Marty J, Larmignat P, Samama C, Cupa M. Residual curarization in the recovery room after vecuronium. Br J Anaesth. 2000;84(3):394-95. Doi: 10.1093/oxfordjournals.bja.a013445.

[4] Weber V, Abbott TE, Ackland GL. Reducing the dose of neuromuscular blocking agents with adjuncts: A systematic review and meta-analysis. Br J Anaesth. 2021;126(3):608-21. Doi: 10.1016/j.bja.2020.09.048.

[5] Baysal A, Dogukan M, Toman H, Sagiroglu G, Kocak T. The use of sugammadex for reversal of residual blockade after administration of neostigmine and atropine: 9AP1-9. Eur J Anaesthesiol. 2013;30:142.

[6] Nicholson WT, Sprung J, Jankowski CJ. Sugammadex: A novel agent for the reversal of neuromuscular blockade. Pharmacotherapy. 2007;27(8):1181-88. Doi: 10.1592/phco.27.8.1181.

[7] Fuchs-Buder T, Meistelman C, Raft J. Sugammadex: Clinical development and practical use. Korean J Anaesthesiol. 2013;65(6):495-500. Doi: 10.4097/kjae.2013.65.6.495.

[8] Menezes CC, Peceguini LM, Silva ED, Simões CM. Use of sugammadex after neostigmine incomplete reversal of rocuronium-induced neuromuscular blockade. Braz J Anaesthesiol. 2012;62(4):543-47. Doi: 10.1016/S0034-7094(12)70153-8.

[9] Answine J. The safe use of sugammadex "rescue" after neostigmine: 2 case reports. Open J Anaesthesiol. 2016;6(9):125-17. Doi: 10.4236/ojanes.2016.69021.

[10] Blobner M, Eriksson LI, Scholz J, Motsch J, Della Rocca G, Prins ME. Reversal of rocuronium-induced neuromuscular blockade with sugammadex compared with neostigmine during sevoflurane anaesthesia: Results of a randomised, controlled trial. Eur J Anaesthesiol. 2010;27(10):874-81. Doi: 10.1097/EJA.0b013e32833d56b7.

[11] Naguib M, Brull SJ, Kopman AF, Hunter JM, Fülesdi B, Arkes HR, et al. Consensus statement on perioperative use of neuromuscular monitoring. Anaesth Analg. 2018;127(1):71-80.

[12] Modi YC, Meena S, Charan P. A comprehensive and prospective analysis to improve patient outcomes in postoperative period by optimizing neostigmine dose and timing with the help of TOF monitoring. Int J Curr Pharm Res. 2023;15(5):126-28. Doi: 10.22159/ijcpr.2023v15i5.3073.

[13] Fuchs-Buder T, Schreiber JU, Meistelman C. Monitoring neuromuscular block: An update. Anaesthesia. 2009;64 Suppl 1:82-89. Doi: 10.1111/j.1365-2044.2008.05874.x.

[14] Thomsen JLD, Mathiesen O, Hägi-Pedersen D, Skovgaard LT, Østergaard D, Gätke MR; INVERT collaborator group. Improving neuromuscular monitoring and reducing residual neuromuscular blockade via e-learning: A multicentre interrupted time-series study (INVERT study). Acta Anaesthesiol Scand. 2022;66(5):580-88. Doi: 10.1111/aas.14038.

PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Anaesthesia, Dr. D. Y. Patil Medical College and Reasearch Centre, Pimpri, Pune, Maharashtra, India.
2. Resident, Department of Anaesthesia, Dr. D. Y. Patil Medical College and Reasearch Centre, Pimpri, Pune, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sania Rodrigues,
Dr. D. Y. Patil Medical College and Reasearch Centre, Pimpri-411018, Pune, Maharashtra, India.
E-mail: drsania631@gmail.com

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