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CASE REPORT

Facial train-of-four monitoring as an evaluation of neuromuscular blockade in a patient with ICU-acquired weakness

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Abstract

Neuromuscular blocking agents are used in the ICU for various reasons, such as during status asthmaticus and patient-ventilator dyssynchrony. We report a 76-year-old man with adenocarcinoma of the oesophagus treated with laparoscopic transthoracic oesophagectomy, which was complicated by a fistula between the gastric reconstruction and the right main bronchus. He developed extensive ICU-acquired weakness and was treated with differential lung ventilation followed by continuous rocuronium infusion. Evaluation of neuromuscular blockade by train-of-four (TOF) stimulation showed a discrepancy in facial and ulnar TOF monitoring. The different number of neuromuscular junctions at each muscle group could be an explanation for this. Therefore, it is suggested to use facial TOF monitoring in ICU patients instead of ulnar TOF monitoring to differentiate between an intoxication of neuromuscular blockade and ICU-acquired weakness.

Introduction

The effect of nondepolarising neuromuscular blocking agents (NMBAs) can be monitored by train-of-four (TOF) stimulation. The TOF is an accelerometer that evaluates the response of innervated muscle by stimulating the innervating nerve. This can be tested at several positions (e.g. ulnar or facial nerve). After neuromuscular blockade, the response to four supramaximal stimuli progressively decreases or disappears. The ratio of the amplitude between the last and the first response is called the TOF ratio. When there is a progressive block, the fourth response disappears, followed by the third, the second and finally the first. This correlates with the degree of neuromuscular blockade.[1]

In the intensive care unit (ICU) more than 25% of the patients who are mechanically ventilated for at least seven days will develop forms of critical illness, also described as ICU-acquired weakness (ICU-AW).[2,3] ICU-AW is due to critical illness myopathy, critical illness polyneuropathy or a combination of the two. Clinically, these patients show signs of systemic weakness and atrophy of all four limbs, accompanied with reduced reflexes. Facial muscle weakness is common, although extraocular muscle weakness rarely occurs.[4] Other risk factors that contribute to the development of ICU-AW are: high severity of illness, sepsis, multiorgan failure, prolonged immobilisation and age (older patients have a higher risk).[5] Patients with acute respiratory distress syndrome (ARDS) form a major group developing ICU-AW.[6]

Monitoring nondepolarising NMBAs in patients in the ICU is challenging because the pharmacokinetics are difficult to predict.[7] This is particularly so in patients with ICU-AW, because they have more risk factors for difficulties in predicting the pharmacokinetics and may benefit from neuromuscular blockade: for example, patients with ARDS where NMBA improves the oxygenation and lowers the risk for barotrauma, although there is no reduction in mortality risk.[8] Bouju et al. described a major discrepancy between clinical assessment and TOF stimulation. Furthermore, in patients with ICU-AW significantly higher total muscular blockade (TOF = 0) was found in comparison with patients without ICU-AW.[9] We do not know of any other study concerning the evaluation of neuromuscular blockade in patients with ICU-AW.

Case report

We report a 76-year-old man with adenocarcinoma of the oesophagus treated with neoadjuvant chemotherapy and radiation therapy followed by laparoscopic transthoracic oesophagectomy, who was admitted to the ICU because of empyema with two rethoracoscopies and drainage. Three months after the initial surgery, a fistula between the gastric

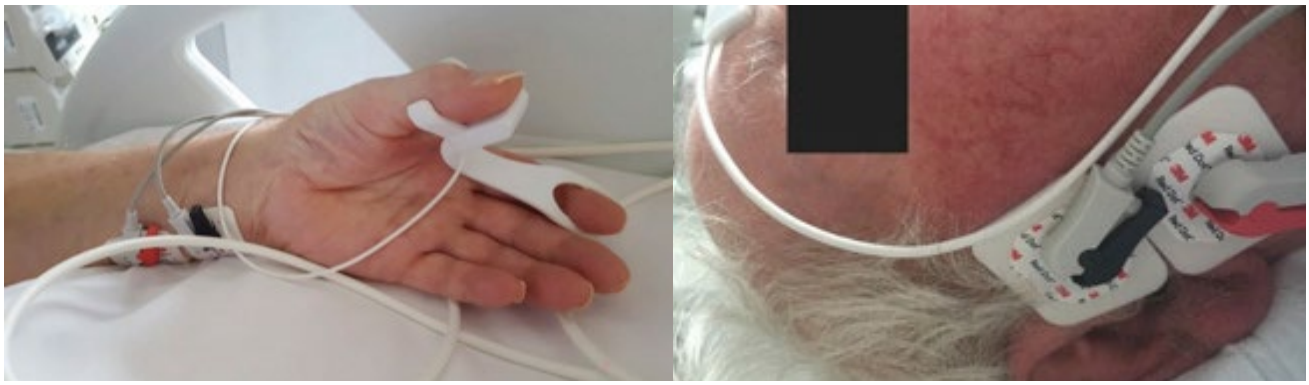

Figure 1. Normal positioning of the electrodes during TOF monitoring at the adductor pollicis muscle (left) and for TOF monitoring at the corrugator supercilii muscle (right).

reconstruction and the right main bronchus was seen and a thoracotomy was performed with correction of the fistula by covering from an intercostal muscle. Because of clinical deterioration and recurrent sepsis syndrome, a rethoracotomy was performed which showed a partly necrotised intercostal muscle with air leakage of the right main bronchus into the gastric reconstruction. This was replaced by another intercostal muscle, but revision of the lesion in the gastric reconstruction was not possible because of the clinically severe catabolic state of the patient. He was treated with differential lung (and prone) ventilation and venovenous extracorporeal CO_2 removal. Continuous rocuronium infusion was administered for two days during this phase.

A TOF monitor was used at the adductor pollicis muscle to evaluate neuromuscular blocking of the ulnar nerve (*figure 1*). There was an absence of twitches (0/4); also the post-tetanic count (PTC) was zero (0/10) which implicated a possible excessive neuromuscular blockade. The continuous infusion of rocuronium was paused. Six hours later monitoring of the adductor pollicis muscle showed the same outcome (TOF 0/4 and PTC 0/10). By replacing the electrodes and force transducer to the eyebrow (at the side of the corrugator supercilii muscle) and on the lateral side of the eye (*figure 1*) a TOF count of 2 was measured (2/4). This disappeared immediately after administration of a 1 mg/kg rocuronium bolus, proving the TOF monitor at the corrugator supercilii muscle was able to show a significant difference in neuromuscular blockade. The following day bronchoscopy showed progression of the fistula. Unfortunately, there was an unfavourable prognosis because of the persistent catabolic state, pulmonary complications and the inability to operate on the fistula. Eventually, in consultation with the family, the ICU treatment was withdrawn and the patient passed away in the presence of his family.

Discussion

We present a patient with severe ICU-AW who had been treated with midazolam for several days and rocuronium for two days because of respiratory failure. Since there was an absence of twitches at the adductor pollicis muscle during TOF stimulation (even after pausing the continuous rocuronium for six hours) we thought this was caused by ICU-AW or an intoxication of NMBAs. After moving the electrodes to the side of the eyebrow, a TOF count of 2/4 was measured, disappearing after a bolus of rocuronium. This suggests ICU-AW.

Not every muscle group responds in the same way to nondepolarising NMBAs. For example, when TOF monitoring is being used at the ulnar side of the adductor pollicis muscle, the twitch response does not accurately reflect neuromuscular transmission in the diaphragm. This is due to the greater blood flow and drug delivery to the central muscles after a bolus of NMBA.[10] Facial muscles are also more resistant to nondepolarising NMBAs, because of more neuromuscular junctions compared with other muscles in the body.[11] A closer look at the facial muscles shows that the corrugator supercilii muscle (at the eyebrow) reflects blockade of the diaphragm and larynx, whereas the orbicularis oculi muscle (at the eyelid) correlates closely with the adductor pollicis muscle.[12] To our knowledge there is only one study (Bouju et al.[9]) that compared the evaluation of neuromuscular blockade by clinical assessment versus facial and ulnar TOF monitoring. They suggested it is more appropriate to monitor facial TOF in ARDS patients for at least the first 48 hours after neuromuscular blockade, in order to provide adequate neuromuscular blockade of the diaphragmatic muscles. Additionally to this finding, we propose that facial TOF monitoring should be considered in patients with ICU-AW receiving neuromuscular blockade or when an intoxication with nondepolarising NMBAs is considered.

Limitations to our observation should be mentioned. First, a baseline TOF count (before the ICU-AW) was not performed. Furthermore, the measurements were not repeated at both locations to check the plausibility of the conclusion after another discontinuation of rocuronium administration. Second, only the ulnar nerve on the left hand was tested, neither the right hand nor the posterior tibial nerve were tested. And third, by using TOF monitoring at the facial corrugator supercilii muscle it is not possible to use the accelerometer and therefore this

technique is not feasible for subtle changes in TOF after four twitches. Finally, no sugammadex was given to discriminate between partial muscle weakness as a result of rocuronium or as a result of ICU-AW. Other studies are needed to investigate the best way of implementing TOF monitoring in the clinical setting on the ICU and in patients with ICU-AW during surgery.

Conclusion

Facial TOF monitoring after neuromuscular blockade seems advisable in patients with ICU-AW instead of ulnar TOF monitoring to evaluate neuromuscular blockade and to exclude NMBA intoxication.

Disclosures

All authors declare no conflict of interest. No funding or financial support was received. Written informed consent was obtained from the family for the publication of this case report.

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