Improving Patient Outcomes with Quantitative ToF Monitoring

CMEO Podcast Show Notes

Residual neuromuscular blockade (NMB) is associated with complications

- Common complications associated with residual NMB: hypoxia, airway obstruction, potential for reintubation, atelectasis, pneumonia, prolonged stay in the post-anesthesia care unit (PACU), overall poor outcomes.[3]
- Residual NMB may not be detected, and symptoms may be attributed to sleepiness or residual opioid effects. Unable to differentiate between residual NMB and other medication effects without quantitative monitoring.

Quantitative monitoring of train-of-four ratio (TOFR) improves patient care

- Nomenclature for NMB monitoring[3]
    - Clinical assessment: Clinicians infer adequate return of neuromuscular function from clinical signs, such as 5-second head lift, tidal volume, and grip strength. Clinical signs, such as the ability to trigger the event or hold the head up, can still be present even in patients with significant weakness.
    - Qualitative monitoring: qualitative devices such as a peripheral nerve stimulator (PNS) deliver a stimulus to a nerve, and the clinician evaluates the elicited muscle response by visual or tactile means. Peripheral nerve stimulators can monitor the degree of and recovery from neuromuscular block with greater sensitivity than clinical assessment, but not to the degree of quantitative monitoring using TOFR.
    - Quantitative assessment: Performed using devices that objectively measure muscle responses elicited from nerve stimulation. Quantitative neuromuscular (QNM) devices can detect minimal blockade by determining the TOF ratio (blockade TOFR 0.4 to 0.89 not detected by peripheral nerve stimulator) and confirm the presence of residual weakness. QNM can be used to identify that adequate recovery of TOFR ≥ 0.9 has been achieved prior to extubation.
- Types of quantitative monitors:
    - Acceleromyography (AMG) uses piezoelectric sensor to measure tissue acceleration with muscle contraction. Devices, such as the Toff watch, have been replaced by newer devices that address previous issues, such as signal-to-noise problems and calibration difficulties.
    - Electromyography (EMG) measures compound muscle action potential and provides a more reliable and precise assessment of muscle strength than clinical or qualitative assessment
        - Unlike other modalities like acceleromyography (AMG) or kinemiography (KMG), EMG does not require a freely moving thumb and can be used even in the tucked arm position.
        - Application of monitor and calibration should ideally occur prior to administration of first dose of NMB for most accurate readings.
    - Kinemyography (KMG) assesses APM contraction by measuring the degree of bending of a sensor placed between the thumb and the first finger. Requires a free thumb or limb for use.
- Areas of future research include using data from EMG monitoring to guide intubation conditions or to target specific levels of blockade.

- Need for education regarding the management of neuromuscular blocking agents and the interpretation of monitor readings.
    - Clinicians may not be aware that the diaphragm can move even at deep levels of blockade, leading to incorrect assessments and decisions about whether or not to administer additional paralytics.[4]
- Ideally, monitoring electrodes should be left on during patient stay in the PACU to allow for reassessment and detection of residual NMB.

Quantitative monitoring in pediatric patients

- EMG has shown promise in pediatric patients. EMG is a great option, especially when pediatric patients need their arms tucked for surgical exposure or for surgeons to reach them.
- Pediatric-sized electrodes are available for use with EMG monitoring equipment. Electrodes are specifically designed to fit even newborns, acknowledging the fact that pediatric patients are not just small adults. The development of these smaller electrodes has made it easier for clinicians to accurately monitor neuromuscular blockade in pediatric patients of different ages and sizes.

Sugammadex in practice: monitoring is still required with use

- When using sugammadex for rocuronium and vecuronium reversal, quantitative TOF monitoring is still required to ensure its desired effect.
- There is heterogeneity in patient response to neuromuscular blocking reversal agents, including sugammadex and neostigmine.
- It is not possible to administer sugammadex blindly using weight-based dosing with the assumption that it will work effectively without any monitoring. This practice of administering a drug without follow-up reassessment is not consistent with the administration of any other drugs in the anesthesia realm (e.g., phenylephrine, ephedrine).
    - Kotake, et al. 2013- The risk of TOFR <0.9 after tracheal extubation after sugammadex was found to be as high as 9.4% in a clinical setting in which neuromuscular monitoring (objective or subjective) was not used.
- There is a bell-shaped curve in regard to patient response to medications, and response to sugammadex is no different. Without monitoring, clinicians cannot ensure optimal recovery or titrate sugammadex dosing based on individual patient response.
    - Bowdle TA, et al.2023- Ninety-seven patients were undergoing cardiac surgery were given sugammadex in 50 mg increments every 5 minutes until TOF 0.9 or greater was obtained. Eighty-four of 97 patients (87%) required less than the manufacturer recommended dose, and 13 (13%) required more. Two patients required additional sugammadex administration for recurrent paralysis.
- Sugammadex, though having a favorable safety profile, is not without risk. Reports have noted hypersensitivity reactions and anaphylaxis, and risk appears to be dose-related. Use of quantitative monitoring can allow for informed decision making about use of sugammadex by providing objective data about the level of NMB.

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Implementing quantitative monitoring may require overcoming obstacles

- One of the main obstacles in implementing quantitative monitoring is addressing the perception among clinicians that they are already skilled enough to assess patients without the need for additional devices. Several studies show that clinicians overestimate their skills in assessing the degree of paralysis.
    - Naguib M, et al. 2019- Survey data of anesthesiologists shows that only 57% were accurate in their knowledge of how to appropriately monitor neuromuscular blockade, yet 84% were confident in their answers, resulting in a 24.6% magnitude of overconfidence. Additionally, this study by Naguib M, et. al determined that anesthesiologists may be reluctant to use objective quantitative monitoring due to the low perceived probability of residual block in any one patient, with the survey results demonstrating that the majority of clinicians feel that the incidence of residual block is < 1%.
- Overconfidence can hinder the adoption of monitoring tools and prevent clinicians from fully utilizing the benefits they offer. Overcoming this obstacle requires a shift in mindset and an understanding that monitoring can significantly improve patient safety and outcomes.
- Time constraints may be cited as a barrier, but studies have demonstrated application of a quantitative monitor takes only 19 seconds.[7]
- Operating room (OR) faculty, including OR and Pre-OP nurses, can be trained to assist with monitor application, further decreasing the burden of time needed to implement use of quantitative monitoring equipment.
- Cost related to acquisition of monitoring devices and specialized sensors can be a barrier to implementing monitoring. However, cost-effectiveness of monitoring in terms of improved patient safety and reduced complications may offset the initial investment needed for new equipment. By emphasizing the long-term benefits and potential cost savings, clinicians/practices may be more encouraged to invest in quantitative monitoring devices.[8]

Quantitative monitoring in special populations

- Patients with obesity are at high risk for developing respiratory complications in the post-operative period. In patients with obesity or edema, there may be an increase in impedance requiring use of higher currents.[4]
- Patients with impaired neuromuscular strength, such as those with paralysis or neuropathy, require some adjustments when using monitoring devices. Understanding the patient's baseline by applying the monitor before administering any NMB is crucial in these cases. The impact of neuropathy, particularly in patients with diabetes, on monitoring at the feet is another important consideration.
- Disease processes that insult the neuromuscular unit, such as diabetic neuropathy, can impact the ability of monitors to work properly, especially in areas of significant nerve damage like the lower extremities and feet.

References

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