

NMB reversal: Assessment

Definition

General Comments

Peripheral nerve stimulators are theoretically the most reliable monitoring method, although visual estimates of TOF are unreliable. Most commonly, electrodes are placed over the ulnar nerve (elbow or wrist, recovers relatively late) or facial nerve (lateral face, recovers relatively early) – the orbicularis oculi (CN VII) more closely reflects blockade of the larynx than the adductor pollicis (ulnar), which is important because while non-depolarizing NMBD onset is more rapid at the vocal cords, it is less intense as compared to peripheral muscles (by contrast, onset of SCh is identical between laryngeal and peripheral nerves). Note that the negative pole (black) should be placed distally for best response

In general, a 90% reduction of the twitch response or elimination of 2 or 3 in the TOF should suffice for intra-abdominal surgery. One does not need to administer NMBDs until past the point of zero twitching – in fact, if no twitches are observed, NMBD should be withheld until at least some motor activity recovers

Inadequate Reversal in the PACU

Berg Study: TOF < 0.7 in Pancuronium

Berg et. al. examined 691 patients who received pancuronium, atracurium, or vecuronium during abdominal, gynaecological, or orthopaedic surgery. Postoperatively, the TOF was measured mechanomyographically. The incidence of residual block (TOF < 0.7), was significantly higher in the pancuronium group (59/226, 26%) than in the atracurium/vecuronium groups (24/450, 5.3%). In the pancuronium group, significantly more patients with residual block developed post-operative pulmonary complications (10/59, 16.9%) as compared to patients without residual block (8/167, 4.8%), however this relationship did not hold for the

atracurium/vecuronium groups (4.2% vs. 5.4%). Multiple regression analysis indicated that abdominal surgery, age, long-lasting surgery, and a TOF ratio < 0.7 following the use of pancuronium were potential risk factors for the development of POPC.

Murphy: TOF for Critical Respiratory Events

Murphy et. al. collected data over a 1 year period in which PACU nurses identified patients with evidence of a critical respiratory event during the first 15 minutes of PACU admission, after which TOF was quantified using acceleromyography. TOF data were also collected in a control group matched by age, sex, and surgical procedure. A total of 61 of 7459 patients developed a CRE after a general anesthetic (42 were matched with controls for statistical analysis – why not all of them?). The most common CREs among matched cases were severe hypoxemia (52.4%) and upper airway obstruction (35.7%, what about the unmatched cases?). Mean (\pm sd) TOF ratios were 0.62 (\pm 0.20) in the CRE cases, with 73.8% of the CRE cases having TOF ratios < 0.70 . In contrast, TOF values in the controls were 0.98 ($p < 0.0001$)

Debaene Study: Recovery from Single Intubating Dose

Debaene et. al. conducted a prospective trial of 526 patients receiving a single intubating dose of intermediate acting non-depolarizing NMBDs and no reversal. They found that even after 120 minutes, $> 30\%$ had a TOF < 0.9 , and $\sim 10\%$ had a TOF < 0.7 as measured with the TOF Watch acceleromyograph. Importantly, they also found that the sensitivity of the qualitative TOF was only 11% for a TOF < 0.9 (and 27% for a TOF < 0.7). Surprisingly, the sensitivity of the head lift was 11% and 19%, respectively.

Summary of Data

TOF of 0.7 is a reasonable cutoff for patients who have received pancuronium, as there is evidence that these patients have a significantly increased risk of complications – these data do not hold for vecuronium patients. Murphy's study showed that the average TOF for patients who

had a critical respiratory event was 0.72, based on TOF accelerometry (ie quantitative measurements). Debaene's data establish the insensitivity of both the head lift and the qualitative TOF to detect residual paralysis, however any conclusions on the decision to reverse must be based on complication rate data

Recent A&A Issue Highlighting NMB (Eight Editorials and Manuscripts)

In July of 2010, *Anesthesia & Analgesia* (Volume 111, Issue 1) published five editorials and three manuscripts regarding neuromuscular blockade, the sum of which suggest that quantitative train of four monitoring should be routine.

Train of Four

Four stimulations at 2 Hz (0.5 seconds between bursts). With non-depolarizing NMBDs, the height of the 4th twitch should be lower than the 1st. A non-depolarizing TOF > 0.7 suggests return to control height. A TOF < 0.3 for SCh suggests phase II blockade (similar to NMBD). Usually, SCh will not display a "fade" between the 1st and 4th stimulations

Questionable Utility of TOF

In addition to being inaccurate (when estimated visually or manually), some authors have criticized the increase in acceptable TOF – Debaene states argues the range of "acceptable" TOF for recovery has gradually increased from 0.7 to 0.9, even though there are no studies comparing the outcome using 0.7 versus 0.9. This of course is countered by Glenn Murphy and Sorin Brull's statement that "Volunteer studies have demonstrated that small degrees of residual paralysis (train-of-four ratios 0.7-0.9) are associated with impaired pharyngeal function and increased risk of aspiration, weakness of upper airway muscles and airway obstruction, attenuation of the hypoxic ventilatory response (approximately 30%), and unpleasant symptoms of muscle weakness".

Double Burst

Because TOF is unreliable both visually or manually, one can give two bursts of 3, separated by 750 msec, which is perceived as two separate twitches. By not feeling the second twitch, the observer's ability to test for a TOF < 0.3 is improved, however the ability to check for TOF > 0.7 is unchanged.

Tetanus

5 seconds of 50Hz. With a non-depolarizing NMBD, the response fades. With SCh, the response is stable but attenuated. If a sustained response is found, then the TOF is probably > 0.7

Summary: Monitoring NMBDs

- Threshold for TOF: need at least 0.9 to minimize risk of post operative complications
- Assessment of TOF: visually or manually unreliable – must use quantitative monitoring
- TOF < 0.3: to test for TOF < 0.3 (if quantitative TOF not available), use double burst testing
- TOF > 0.7: to test for TOF > 0.7 (if quantitative TOF not available), use tetanus

Causes of upregulations of NACHR

Definition

Upregulation of Acetylcholine receptors leads to increased sensitivity to Succinylcholine and risk for hyperkalemia due to depolarization of the muscle membrane. May occur in:

- 1) Spinal Cord Injury
- 2) Stroke

3) Burns

- After immobilization, upregulation of NACHRs
- Avoid Succinylcholine – especially after 24 hours post burn and for up to 1-2 years post burn (may take months to years to return to preburn levels of NACHR)
- Resistance to nondepolarizing NMBDs and increased sensitivity to succinylcholine

4) Prolonged immobility

5) Prolonged exposure to neuromuscular blockers

- Typically seen in ICUs to facilitate mechanical ventilation, tetanus, status epilepticus, reduction in oxygen consumption

6) Multiple Sclerosis

- Demyelination of the CNS
- Attention autonomic dysfunction

7) Guillain Barre' syndrome

- Demyelination and axonal degeneration produce functional denervation of muscle and upregulation of NAChRs at the postsynaptic membrane
- Pay attention to autonomic dysfunction
- Maintain adequate preload, temperature control, postural changes, blood loss