PURPOSE:
1. To ensure the administration of the lowest and most effective dose of pharmaceutical agent needed to achieve neuromuscular blockade.

2. To reduce the risk of prolonged paralysis and monitor for potential complications in patients receiving neuromuscular blockage.

DEFINITIONS:
Peripheral Nerve Stimulation—The delivery of an electrical stimulus to the motor nerve and monitoring of the muscle response.

Train-of-Four (TOF) Stimulation—A method of monitoring neuromuscular blockade involving four electrical stimuli of 10mA to 80mA delivered at intervals of 0.5 seconds and palpating/observing the muscle response. Sites most commonly utilized for TOF testing are: the ulnar, facial, posterior tibial, and peroneal. The ulnar nerve, which innervates the adductor pollicus muscle, is the most widely used.

Paralysis—No movement, voluntary or involuntary. No spontaneous ventilation.

KNOWLEDGE BASE:
Neuromuscular blocking drugs (NMBDs) are given in the critical care unit, along with sedatives and opioids, most commonly to:

1. Facilitate mechanical ventilation and control airway pressure when analgesics and sedatives are not effective.

2. Minimize oxygen consumption in patients with severe hemodynamic instability and/or oxygen delivery.

3. Diminish muscle rigidity in tetanus.

4. Assist with the management of increased intracranial pressure in the brain-injured patient.

5. Augment cooling in hypothermia protocols for cardiac arrest and acute ischemic stroke.

5. Facilitate a motionless state in patients with unstable
surgical wounds.

6. Facilitate procedures (i.e., endotracheal intubation).

NMBDs do not affect sensation or level of consciousness. Because NMBDs lack amnesic, sedative and analgesic properties, sedatives and analgesia should always be given concurrently to minimize the patient’s awareness of blocked muscle activity and discomfort.

The train-of-four (TOF) method of stimulation is most commonly used for ongoing monitoring of NMBD use to reduce the risk of overdose, prevent prolonged paralysis, and monitor individual response to a particular medication and/or dose. After delivery of four successive stimulating currents to a select peripheral nerve with the PNS, in the absence of significant neuromuscular blockade, four muscle twitches follow. The four twitches indicate that 75% or fewer of the receptors are blocked. Blockade is quantified by counting the muscle responses to the electrical TOF stimulation. The number of responses observed indicate the degree of neuromuscular blockade (paralysis). As the depth of blockade increases, the number of elicited responses decreases.

TOF Testing:

a. 4 out of 4 twitches: 75 % or less
b. 3 out of 4 twitches: 80% paralysis
c. 2 out of 4 twitches: 85% paralysis
d. 1 out of 4 twitches: 90% paralysis
e. 0 out of 4 twitches: 100% paralysis

Unless specified by the physician, the desired level of neuromuscular blockade will be two (2) to four (4) out of four (4) twitches, (or 75-85% paralysis).

Numerous medications, such as aminoglycosides and other antibiotics, beta blockers, calcium channel blockers, corticosteroids, and anesthetics, and various conditions, such as acidosis and electrolyte imbalances, potentiate the effects of neuromuscular blocking agents. Thus, the level of blockade is subject to variation, which necessitates vigilant monitoring with a PNS and titration of the NMBD.

PROCEDURE:

Note: Baseline assessment should be done before NMBD is started.

1. An artificial airway MUST be in place and airway patency maintained at all times.

2. All alarms must be functional with appropriate parameters set for the patient.

3. Maximum analgesia and sedation must be administered.
RASS MUST BE -4 BEFORE STARTING neuromuscular blocking agent. Titrate both analgesia and sedation prior to initiating neuromuscular blocking agent.

**(Goal for titrating neuromuscular blocking agent is patient-ventilator synchrony)**


5. Ideally, the TOF baseline should be determined prior to the administration of the neuromuscular blocking agent.

6. Perform hand hygiene.

7. Don gloves.

8. Site should be hairless, cleaned with an alcohol pad, and allowed to dry.

9. Assess for best location for electrode placement: consider avoidance of areas that are edematous or extremities where there is hemiplegia, or peripheral neuropathies. Commonly used sites include the ulnar nerve, facial nerve, and the posterior tibial nerve.

10. Electrodes are placed along the path of the nerve being tested.

11. Connect the cables to the electrodes. Connect the negative (black) lead to the distal electrode and the positive (red) lead to the proximal electrode. (Red closest to the heart).

12. Turn on the PNS and select current.

**For baseline assessment before NMBD started:**

- Start with 10 mA for baseline assessment.
- Depress TOF key. Through visual and tactile assessment, count number of twitches.
- Increase mA until four twitches are observed.
- Record stimulator settings on computerized flowsheet as baseline setting (also known as Supramaximal Stimulation (SMS) level).

7. Begin NMBD as ordered.

RASS MUST BE -4 BEFORE STARTING neuromuscular blocking agent. Titrate analgesics and sedation prior to initiating neuromuscular blocking agent.

**(Goal for titrating neuromuscular blocking agent is patient-ventilator synchrony)**
Tritrate neuromuscular blocking agent to lowest effective dose.

**GOAL TOF is 2-4 of 4 twitches once oxygenation goal has BEEN ACHIEVED**

- If oxygenation goals are met, there is no need to increase the dose.

For subsequent assessments:
- Repeat TOF testing, using the baseline setting every 30 minutes until ordered level of neuromuscular blockade has been achieved times two consecutive TOFs. Then monitor TOF q 2 hours times two then q4 hours thereafter as long as NMBD is not being titrated.
- If no twitch is elicited, stop the infusion of NMBD and monitor TOF testing every 15 minutes until ordered level of neuromuscular blockade is reached, then restart the NMBD infusion at 50 % of the previous dose.
- If no twitch is elicited and infusion decreased by 50 %: monitor TOF q 30 minutes times two, then q2 hours times two, then q 4 hour thereafter as long as NMBD is not being titrated.

8. Remove gloves and discard.


10. A wake-up assessment MUST be performed every twenty-four (24) hours by turning off the NMBD followed by the sedative after the patient is showing movement in their hands/feet to allow for the evaluation of the patient's neurological function, unless otherwise contraindicated. If contraindicated an MD order placing the “Wake up assessment” on hold must be obtained. Assessment must be documented in the EHR.

11. The clinician should be aware that certain other medication and/or clinical conditions might prolong or enhance neuromuscular blockade. These include: simultaneous administration of steroids, renal failure, or liver failure.

12. The clinician MUST maintain adequate sedation and analgesia during administration of neuromuscular blockade. Doses of sedatives and analgesics should not be titrated down while the patient is still on a NMBD (Use autonomic responses to pain or anxiety, such as tachycardia, hypertension, and sweating to assess adequacy of sedation and analgesia).

13. During neuromuscular blockade, the clinician must
provide meticulous skin care and eye care to prevent complications, such as pressure ulcers or corneal abrasions.

Reversal:

a. Reversal agents for NMB agents must be quickly accessible via the critical care satellite pharmacy.

b. The speed of reversal of residual neuromuscular blockade is primarily determined by the depth of blockade at the time of reversal. Once four (4) out of four (4) twitches are demonstrated by TOF testing and there is movement in the hands/feet, the recovery is probably satisfactory.

EXCEPTIONS:

None

EXPECTED OUTCOME:

Titration of these drugs according to clinical assessment and muscle twitch response should help to provide a sufficient level of blockade without overshooting the goal. Overshooting the level of blockade with use of excessive doses of NMBDs is of special concern because it may predispose the patient to prolonged paralysis and muscle weakness, as reported extensively in the literature. Monitoring with a PNS during the administration of NMBDs results in the use of less medication, hastens recovery of spontaneous ventilation, and accelerates restoration of neuromuscular transmission, which is necessary for resumption of muscle activity. Although some patients have severe muscle weakness after neuromuscular blockade, peripheral nerve monitoring during NMBD therapy facilitates prompt recovery of neuromuscular transmission when therapy is terminated.

REFERENCES:

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