

NEUROMUSCULAR MONITORING

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Objectives of NM Monitoring

- Monitoring onset of NM Blockade.
- To determine level of muscle relaxation during surgery.
- Assessing patients recovery from blockade to minimize risk of residual paralysis.

Why do we Monitor?

- Residual post-op NM Blockade
 - Functional impairment of pharyngeal and upper esophageal muscles
 - Impaired ability to maintain the airway
 - Increased risk for post-op pulmonary complications
 - Difficult to exclude clinically significant residual curarization by clinical evaluation

Who should be Monitored ?

- Patients with severe renal, liver disease
- Neuromuscular disorders like myasthenia gravis, myopathies, UMN and LMN lesions
- Patients with severe pulmonary disease or marked obesity
- Continuous infusion of NMBs or long acting NMBs
- Long surgeries or surgeries requiring elimination of sudden movement

Principles of Peripheral Nerve Stimulation

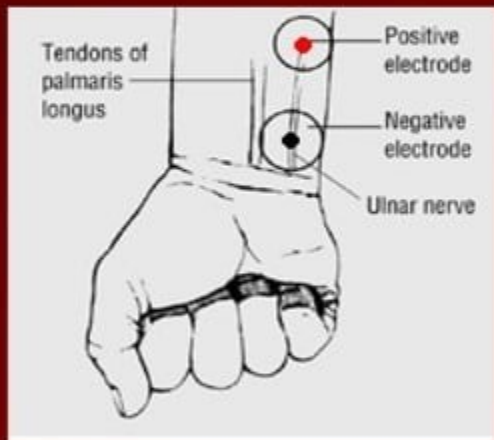
- Each muscle fiber to a stimulus follows an all-or-none pattern
- In contrast, response of the whole muscle depends on the number of muscle fibers activated
- Response of the muscle decreases in parallel with the numbers of fibers blocked
- Reduction in response during constant stimulation reflects degree of NM Blockade
- For this reason stimulus is supramaximal

Electrodes

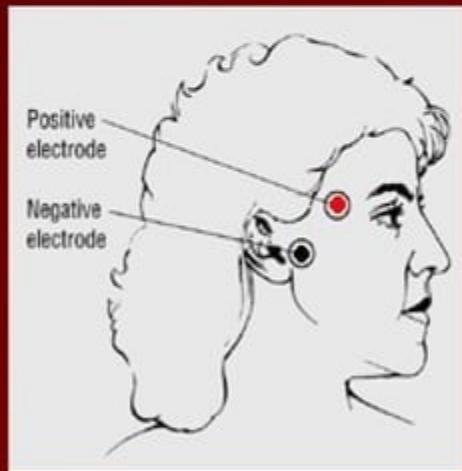
- Surface electrodes
 - Pregelled silver chloride surface electrodes for transmission of impulses to the nerves through the skin
 - Transcutaneous impedance reduced by rubbing
 - Conducting area should be small(7-11mm)
- Needle electrodes
 - Subcutaneous needles deliver impulse near the nerve

Electrode placement:

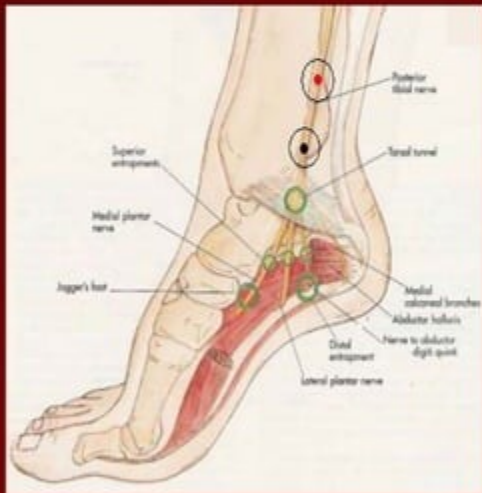
- **Ulnar nerve:** place negative electrode (black) on wrist in line with the smallest digit 1-2cm below skin crease
- positive electrode (red) 2-3cms proximal to the negative electrode
- • Response: Adductor pollicis muscle – thumb adduction



- **Facial nerve: place negative electrode (black) by ear lobe and the positive (red) 2cms from the eyebrow (along facial nerve inferior and lateral to eye)**
- **Response: Orbicularis oculi muscle – eyelid twitching**



- Posterior tibial nerve:**
 place the **negative electrode (black)** over **inferolateral aspect of medial malleolus** (palpate posterior tibial pulse and place electrode there) and positive electrode (red) 2-3cm proximal to the negative electrode
- Response: Flexor hallucis brevis muscle – planter flexion of big toe



Patterns of Stimulation

- Single-Twitch Stimulation
- Train-of-Four Stimulation
- Tetanic Stimulation
- Post-Tetanic Count Stimulation
- Double-Burst Stimulation

Single-Twitch Stimulation

- Single supramaximal stimuli applied to a nerve at frequencies from 1.0Hz-0.1Hz
- Height of response depends on the number of unblocked junctions
- Prerelaxant control value is needed
- Does not detect receptor block of <70%
- Used to assess potency of drugs
- Stimulation dependent onset time

Single-Twitch Stimulation

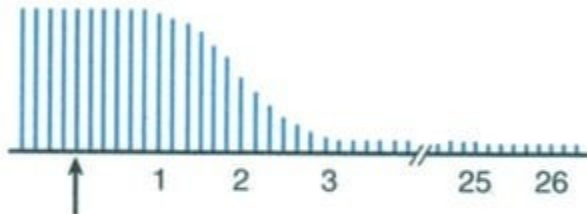
0.1–1.0 Hz.

Stimulation:

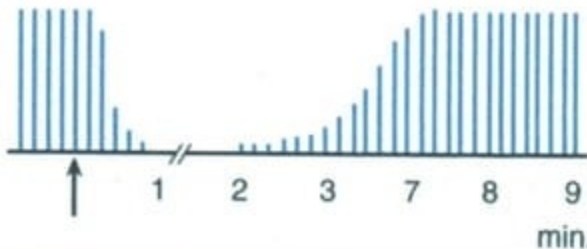


Response:

Non-dep.
block:



Dep.
block:



Train-of-Four Stimulation

- Four supramaximal stimuli are given every 0.5 sec
- “Fade” in the response provides the basis for evaluation
- The ratio of the height of the 4th response(T_4) to the 1st response(T_1) is TOF ratio
- In partial non- depolarizing block T_4/T_1 ratio and is inversely proportional to degree of blockade
- In partial depolarizing block, no fade occurs in TOF ratio
- Fade, in depolarizing block signifies the development of phase II block

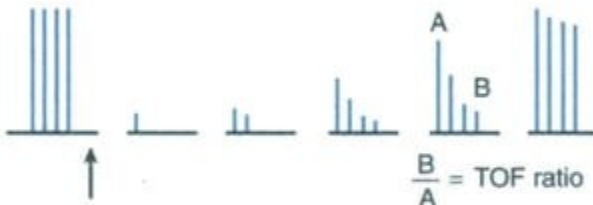
Train-of-Four Stimulation

Stimulation:



Response:

Non-dep.
block:



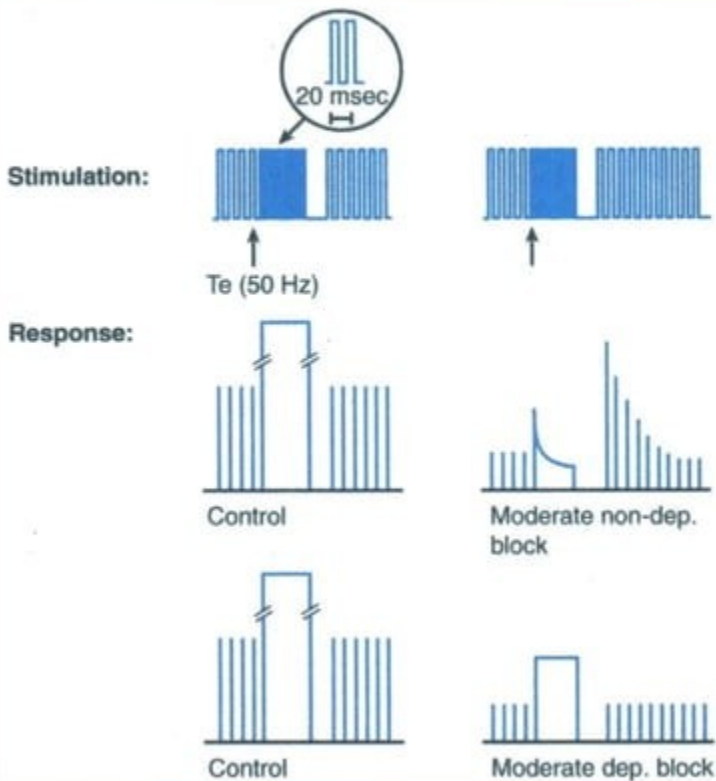
Dep.
block:



Tetanic Stimulation

- Tetanic Stimulation is 50-Hz stimulation 50Hz given for 5 sec
- During normal NM transmission and pure depolarizing block the response is sustained
- During non- depolarizing block & phase II block the response fades
- During partial non- depolarizing block, tetanic stimulation is followed by post-tetanic facilitation

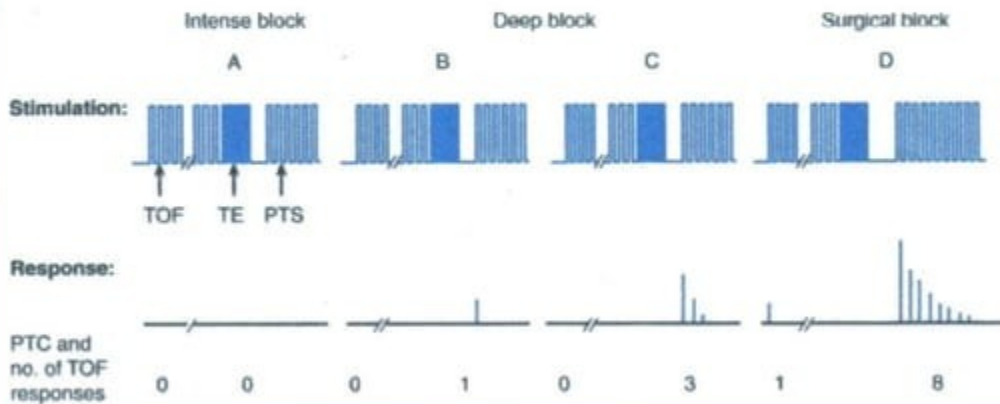
Tetanic Stimulation



Post-Tetanic Count Stimulation

- Used to assess degree of NM Blockade when there is no reaction single-twitch or TOF
- Number of post-tetanic twitch correlates inversely with time for spontaneous recovery
- Tetanic stimulation(50Hz for 5sec.) and observing post-tetanic response to single twitch stimulation at 1Hz,3sec after end of tetanic stimulation
- Used during surgery where sudden movement must be eliminated(e.g., ophthalmic surgery)
- Return of 1st response to TOF related to PTC

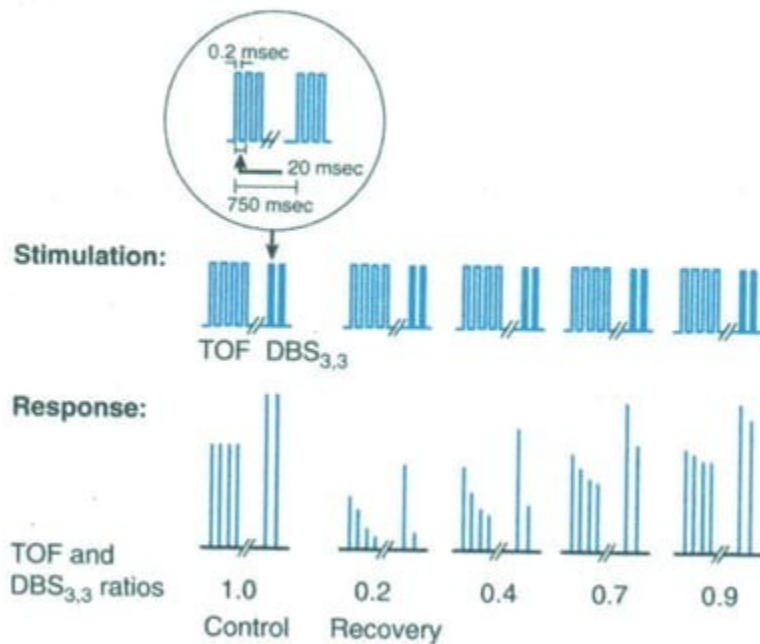
Post-Tetanic Count Stimulation



Double-Burst Stimulation

- DBS consist of two train of three impulses at 50Hz tetanic stimulation separated by 750msec
- Duration of each impulse is 0.2msec
- DBS allow manual detection of residual blockade under clinical conditions
- Tactile evaluation of fade in DBS_{3,3} is superior to TOF
- However, absence of fade by tactile evaluation to DBS does not exclude residual NM Blockade

Double-Burst Stimulation



Feature	ST	TOF	Tetanus	DBS	PTC
Current strength	Supra-maximal	Supra or submaximal	Supra or submaximal	Supra or submaximal	Supra or submaximal
Frequency / Description	0.1 to 1 Hz	2 Hz four stimuli	30-50 Hz for 5 sec	3 impulses at 50 Hz repeated after 750 msec.	30 Hz for 5 sec, 3 sec later ST at 1Hz
Prerelaxant Control	Needed	Not needed	Not needed	Not needed	Not needed
Pain on stimulation	-	- / +	++	+	++
Sensitivity of manual detection (visual/tactile)	Not sensitive	Not sensitive at TOF ratio of 0.4-0.7	Sensitive	Highly sensitive	Sensitive
Alteration of subsequent responses	Not altered	Not altered	Altered (post-tetanic facilitation)	Not altered	Altered
Interval between successive stimuli	5 sec	12 sec	6 min	12-15 sec	6 min
Receptor occupancy detection	75-90%	70-90%	70-90%	70-90%	>90% also
Sensitivity for detection of subtle block	Not sensitive	Sensitive	Sensitive	Sensitive	Not applicable
Monitoring of profound block	Not useful	Not useful	Not useful	Not useful	Useful

Non-depolarizing blockade

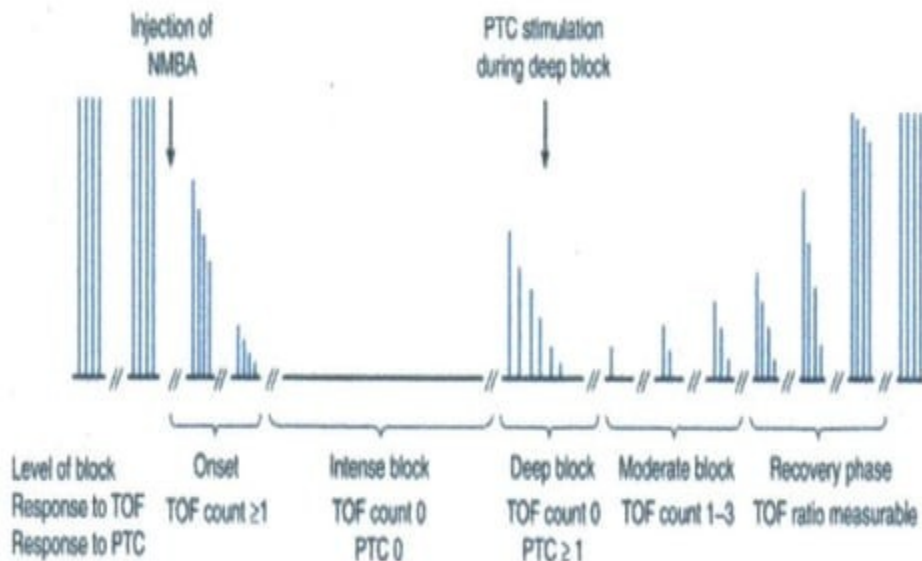
- Intense NM Blockade
 - This phase is called “Period of no response”
- Deep NM Blockade
 - Deep block characterized by absence of TOF response but presence of post-tetanic twitches
- Surgical blockade
 - Begins when the 1st response to TOF stimulation appears
 - Presence of 1 or 2 responses to TOF indicates sufficient relaxation

Contd...

- Recovery
 - Return of 4th response to TOF heralds recovery phase
 - presence of spontaneous respiration is not a sign of
 - adequate neuromuscular recovery.
 - T_4/T_1 ratio > 0.9 exclude clinically important residual NM

Blockade

- Antagonism of NM Blockade should not be initiated before at least two TOF responses are observed



Depolarizing NM Blockade

- Phase I block
 - Response to TOF or tetanic stimulation does not fade, and no post-tetanic facilitation
- Phase II block
 - “Fade” in response to TOF in depolarizing NM Blockade indicates phase II block
 - Occurs in pts with abnormal cholinesterase activity and prolonged infusion of succinylcholine

Clinical tests of Postoperative Neuromuscular Recovery

Reliable	Unreliable
Sustained head lift for 5 sec	Sustained eye opening
Sustained leg lift for 5 sec	Protrusion of tongue
Sustained handgrip for 5 sec	Arm lifted to the opposite shoulder
Sustained “tongue depressor test”	Normal tidal volume
Maximum inspiratory pressure 40 to 50 cm H ₂ O or greater	Normal or nearly normal vital capacity
	Maximum inspiratory pressure less than 40 to 50 cm H ₂ O

Limitations of NM Monitoring

- Neuromuscular responses may appear normal despite persistence of receptor occupancy by NMBs.
- $T_4:T_1$ ratios is one even when 40-50% receptors are occupied
- Patients may have weakness even at TOF ratio as high as 0.8 to 0.9
- Adequate recovery do not guarantee ventilatory function or airway protection
- Hypothermia limits interpretation of responses

THANK YOU !