**Pharm-10A2** Describe the methods of determining depth of neuromuscular block and list the advantages and limitations of each.

**Background**

The depth of neuromuscular blockade can be assessed in the following ways:

1. **Clinical parameters**
   - ability to perform certain actions

2. Using a peripheral nerve stimulator with different modes of stimulation:
   - single twitch
   - train of four
   - double burst stimulation
   - tetanus
   - post-tetanic count

With either subjective or objective monitoring (e.g. acceleromyography, mechanomyography, EMG)

**Clinical Parameters**

Ability to perform specific actions e.g.:
- sustained head lift (e.g. for 5 seconds)
- generate adequate maximal inspiratory pressures and tidal volumes
- hand grip strength

However, clinical parameters are all unreliable, demonstrate significant inter-assessor variability and also correlate poorly with objective testing of neuromuscular function

**Peripheral Nerve Stimulation**

**Single twitch**

**Method:** Single square wave supramaximal stimulus lasting 0.2 ms applied at regular intervals → baseline twitch height is measured and compared with subsequent twitch heights (shown below)

![Twitch height graph]

(source: McGrath and Hunter, CEACCP 2006)

Twitch height begin to reduce at ~ 75% receptor occupancy with ND-NMBs
Uses: assess development of block at induction

Advantages: easy to perform

Disadvantages: require knowledge of baseline twitch height, very crude assessment

**Train of Four**

**Method:** four supramaximal stimuli each lasting 0.1 msec, delivered at 2 Hz. Whole train is repeated every 10 seconds. Number of twitches felt clinically = TOF number \( \rightarrow \) reflects receptor occupancy. T4 (height of fourth twitch) is compared with T1 = TOF ratio \( \rightarrow \) reflects fade

Result:
For non-depolarising NMBs:
- TOF number = 0 \( \rightarrow \) approx 100% receptors blocked
- TOF number = 1 \( \rightarrow \) 90% receptors blocked
- TOF number = 2 \( \rightarrow \) 80% receptors blocked
- TOF number = 3 \( \rightarrow \) 70% receptors blocked
- TOF number = 4 \( \rightarrow \) < 70% receptors blocked
- TOF (T4:T1) ratio > 0.9 \( \rightarrow \) adequate for extubation

Uses: assess recovery from moderate to deep block with non-depolarising NMBs; TOF is less useful for monitoring block from suxamethonium

Advantages: able to assess TOF number visually, not very painful

Disadvantages: TOF ratio requires objective measurement \( \therefore \) may be difficult to assess superficial blocks subjectively

**Double Burst Stimulation**

**Method:** two bursts separated by 750 msec, each burst consists of three supramaximal stimuli at 50 Hz, each lasting 0.2 msec.
Compare the twitch height of first burst with twitch height of second burst detects more subtle fade

**Uses:** detect subtle fade associated with superficial blocks by ND-NMBs  
**Advantages:** easy to perform, better than subjective TOF for superficial blocks  
**Disadvantages:** more painful than TOF; no better than TOF when objective measurement is used

**Tetanus**

**Method:** burst of rapid (50 ~ 200 Hz) stimuli (each lasting 0.1 msec), maintained for 5 seconds monitor strength of contraction for subtle fade  
Usu. 50 Hz used as with higher frequencies, muscle may display fatigue

**Uses:** detect subtle fade associated with superficial blocks by ND-NMBs; potentiates NMJ post tetanic count  
**Advantages:** extremely sensitive for fade (with ND-NMBs)  
**Disadvantages:** very painful and not suitable for awake patients

**Post-Tetanic Count**

**Method:** first apply tetanic stimulation (0.1 msec stimuli at 50 Hz maintained for 5 sec) 3 second pause repeated single twitch (0.1 msec) at 1 Hz subjectively measure number of single twitches

Tetanic stimulation results in ACh synthesis and mobilisation immediate increase in available ACh store momentary increased response to subsequent supramaximal stimuli post-tetanic facilitation

**Result:** first TOF twitch returns approximately with post-tetanic count of 9

**Uses:** assess recovery from deep blockade (when TOF number of zero observed)  
**Advantages:** sensitive in deep paralysis  
**Disadvantages:** very painful
Objective Monitoring

TOF ratio is difficult to assess visually
∴ can use objective monitoring

(1) Acceleromyography
Stimulate nerve → measure acceleration of contracting muscle (using accelerometer)
→ proportional to force of contraction

Accelerometer is usu. a small piezoelectric wafer strapped to contracting muscle → converts acceleration to voltage

(2) Mechanomyography
Stimulate nerve → directly measure force of isometric muscle contraction (using strain gauge)

(3) Electromyography
Cumbersome, prone to diathermy interference → rarely used

Examiner’s comments – 64% of candidates passed this question.

This question covers material asked in previous questions. The main points expected for a pass include: neuromuscular blockade can be assessed by both clinical means and by using the nerve stimulator. Some examples of clinical means (e.g., head lift for 5 seconds) was expected, however clinical methods are unreliable.

The characteristics of the required impulses from the nerve stimulator afforded the candidates points.

Marks were awarded for the different modes of stimulation, such as single twitch, train of four count and ratio, double burst stimulation, tetany and post tetanic count. It was expected that candidates would describe their requirements, their advantages and disadvantages and how best to clinically utilise them for e.g., for reversal, in deep block. Some candidates went into great detail about the neuromuscular junction, which afforded them no marks.

The concept that the strength of the muscular twitches produced is related to receptor occupancy by the neuromuscular blocker and at what levels of occupancy one could expect how many twitches. A few candidates did not appreciate that with a train of four count of 4, there was still a 70% receptor occupancy by the drug. Some thought that with a post tetanic count of 10, it was reasonable to reverse the patient with conventional reversal agents.

Bonus marks were awarded if there was demonstration of how the depolarising and nondepolarising blocks differed in their responses to the nerve stimulator, the different sensitivities of different muscle groups to the neuromuscular blocker and mention of acceleromyography or more sophisticated methods. Use of diagrams implied understanding and where appropriate, garnered marks. Some candidates were confused about the TOF ratio, saying it was the ratio of the height of the first twitch compared to the fourth twitch.