CLINICAL USE OF PERIPHERAL NERVE STIMULATORS

The Neuromuscular Junction

The impulse passing down a motor nerve is transmitted to a muscle across the motor end plate or neuromuscular junction. The transmission of this impulse is mediated via acetylcholine, which becomes attached to specific receptors sites on the motor end plate. In general terms, it is blockade of transmission across the neuromuscular junction by muscle relaxants that produces muscle relaxation.

Although all muscle relaxants act on the neuromuscular junction, the mode and duration of action and intensity of blockade differ for different agents. These specific aspects of the action of neuromuscular agents can be differentiated by nerve stimulation.

Depolarizing and Non-Depolarizing Blockade

Physiological conduction across the neuromuscular junction is by depolarization of the motor end plate by acetylcholine. This depolarization is of exceedingly short duration.

Depolarizing relaxants such as succinylcholine chloride cause depolarization of the end plate but the recovery period is much greater and extends to minutes rather than milliseconds. Prolonged depolarization causes neuromuscular blockade.

Non-depolarizing relaxants such as d-tubocurarine chloride do not cause depolarization; rather they occupy the specific receptor sites on the motor end plate. This prevents acetylcholine from attaching to the receptor sites. The duration of action of these drugs is probably dependent on how long they occupy she receptor sites.

The difference in the type of blockade produced by the depolarizing or non-depolarizing relaxants accounts for their differing response to nerve stimulation.

Detection of the Type of Neuromuscular Blockade-General

Depolarizing blockade is associated with in intensity of muscle response to nerve stimulation. Non-depolarizing blockade is accompanied by a change in the character, as well as the intensity of the muscle response to nerve stimulation. These different types of responses are described in more detail below.

Depolarizing Blockade

The drug most commonly used for short-term muscle relaxation is succinylcholine chloride, which produces a depolarizing neuromuscular blockade. Figure 1 illustrates the normal progression of degree of relaxation following administration of succinylcholine chloride. A dose of 0.7 mg per kg generally produces complete abolition of the muscle response to nerve stimulation. After a varying interval (approximately 2 to 2.5 minutes) the neuromuscular junction starts to recover. There will then be a slight but consistent response to a Train-of-Four stimulus. A tetanic stimulus (50 per second) will produce a tetanic response of small but sustained intensity. Train-of Four stimulus applied after the tetanic stimulus produces a muscle response equal in intensity and character to the original series of stimuli. In other words, there will be no Wedensky inhibition (fade of tetanus) and no post-tetanic facilitation.

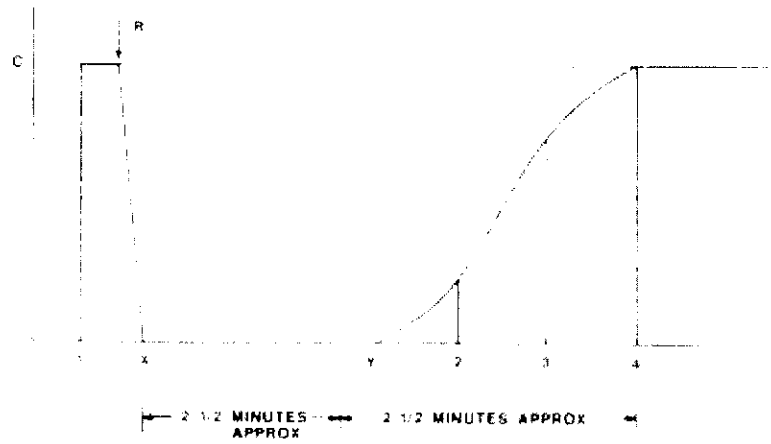

Figure 1 - Depolarizing Blockade Recovery Curve

The height(C) represents a normal control response of muscle contraction to nerve stimulation. Succinylcholine chloride is administered at point R. During the interval of X-Y, there is no response to nerve stimulation. Stimulation during recovery at points 2 and 3 will then show increasing intensity of response to nerve stimulation. Stimulation at point 4 will produce a response of equal intensity to the control response at point 1, showing full recovery.

Sequence in Testing for Wedensky Inhibition ("fade" of tetanus) and Post-Tetanic Facilitation

Normally a set sequence is used to test for Wedensky inhibition and post-tetanic facilitation. Figure 2 compares the response of a depolarizing blockade to a control response.

The nerve is stimulated in the following manner:

1. The nerve is stimulated with a Train-of-Four stimulus by pressing the Train-of Four key momentarily.
2. The nerve is then subjected for 3 to 4 seconds to a tetanic series of stimuli at 50 per second by pressing and holding the 50 Hz Tetanus key.
3. After a pause of one to two seconds, the nerve is again stimulated as in Step 1.

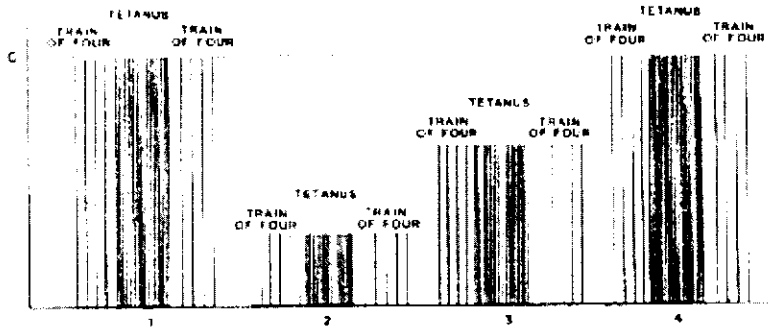

Figure 2 - Depolarizing Blockade Muscle Response Pattern

The Train-of-Four/Tetanus/Train-of-Four stimulus pattern is repeated at intervals 1, 2, 3 and 4. The intensity of responses is represented by the height of the lines in the diagram. In depolarizing blocks, the intensity, not the character of the response, is changed.

Non-Depolarizing Blockade

There is a large degree of variation in response to non-depolarizing relaxants dependent on many factors in addition to the initial dose. These relaxants are often administered on an average-dose basis, but the exact response to any dose in a particular patient can be assessed by use of MiniStim IIIA. Furthermore, the duration of action may be observed visually without dependence on clinical impressions.

Figure 3 illustrates the normal progression of blockade following administration of d-tubocurarine chloride.

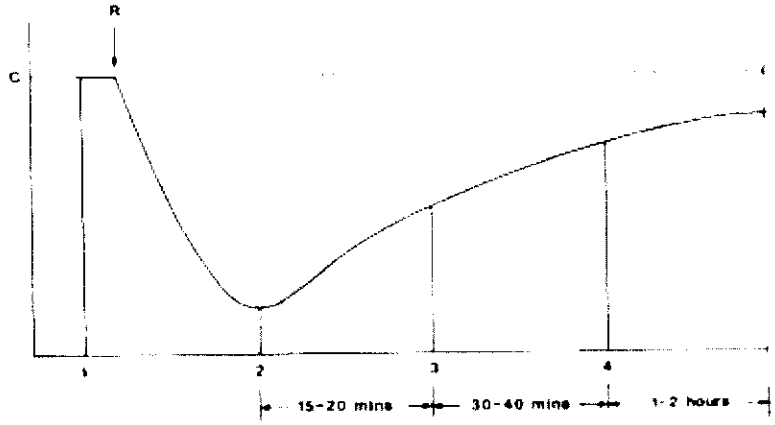

Figure 3 - Non-Depolarizing Blockade Recovery Curve

D-tubocurarine chloride is administered at point R. The sequence described for demonstrating Wedensky inhibition and post-tetanic facilitation is carried out at 1, 2, 3, and 4. The response Patterns are illustrated diagrammatically in Figure 4.

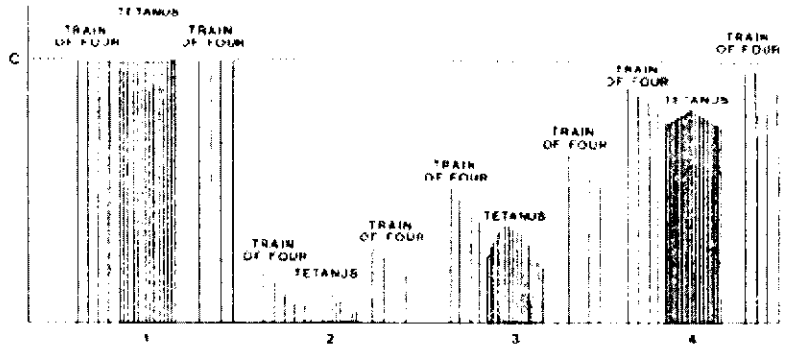

Figure 4 - Non-depolarizing Blockade Muscle Response Pattern

The Train-of-Four/Tetanus/Train-of-Four stimulus pattern is repeated at intervals 1, 2, 3, and 4. The following important features are illustrated:

1. At interval 2, the initial response to a single Train-of-Four stimulus rapidly diminishes and may disappear completely. The tetanus response is poorly sustained (Wedensky inhibition), but the response to a single Train-of-Four stimulus the tetanus stimulation is increased (post-tetanic facilitation).
2. At interval 3, Wedensky inhibition is harder to detect visually but post-tetanic facilitation is clearly visible.
3. At interval 4, Wedensky inhibition is almost impossible to detect visually but, nevertheless, post-tetanic facilitation can be detected.

The fade-off of response intensity to the initial Train-of Four stimulus is harder to detect when the degree of neuromuscular blockade is slight.

Reversal of Non-Depolarizing Relaxants

Normally at the end of surgery, the residual effects of non-depolarizing relaxants are reversed with atropine

and neostigmine. The dosage is often empirical, based on experience and clinical observation of the patient's response. MiniStim IIIA provides a means of objectively monitoring the dosage of the reversing agent. For example, neostigmine can be administered in incremental doses until Wedensky inhibition or post-tetanic facilitation disappears - thus objectively confirming absence of residual curarization, which could cause post-operative respiratory depression.

Usually, it is not possible to reverse the effects of non-depolarizing relaxants while there is marked fade of tetanic response to nerve stimulation, or when no muscle response at all can be demonstrated to a tetanic stimulation.

Abnormal Response to Muscle Relaxants

The importance of abnormal or reduced pseudo-cholinesterase levels is well known to the anesthetist. The very prolonged relaxation produced by succinylcholine chloride in patients with this abnormality is well documented. MiniStim IIIA will quickly detect any such prolongation and permit minute-to-minute assessment of the patient's state of relaxation.

When using succinylcholine chloride intermittently or combined with a potentiating agent, the development of a non-depolarizing element to the neuromuscular blockade will be detected rapidly when monitoring continuously with the MiniStim IIIA. An example of such a situation is occurrence of post-tetanic facilitation during the recovery phase after administration of succinylcholine chloride.

In certain types of surgery, sudden unwanted movement can be dangerous. Continuous monitoring of neuromuscular transmission enables incremental doses of relaxant to be administered in time to prevent this from occurring. This is of particular value when using intermittent succinylcholine chloride techniques.

The Train-of Four

The response to a brief train of stimuli is a more sensitive index of receptor blockade by a competitive neuromuscular blocking agent than is the response to a single twitch. Also, the Train-of-Four stimulus may produce less discomfort in a conscious patient than a tetanic stimulus.

Press the Train-of-Four key to produce four pulses at a frequency of two pulses per second. Four pulses are chosen because it has been found that during partial curarization, the fourth response is usually maximally depressed. The ratio of the amplitude of the fourth response to the amplitude of the first response in the train is a widely used measurement of the degree of neuromuscular blockade.

Double Burst

Double Burst Stimulation is a new pattern of stimulation developed to reveal residual neuromuscular blockade. DBS 3/3 consists of three pulses spaced 20 milliseconds apart followed 3/4 of a second later by a second group of three pulses similarly spaced (Figure 5).

In the non-paralyzed muscle, the response to DBS 3/3 is two short muscle contractors of equal strength. In the partially paralyzed muscle, the second response is weaker than the first - i.e. there is fade in the response.

Press the DBL BURST key to produce the Double Burst stimulus pattern.

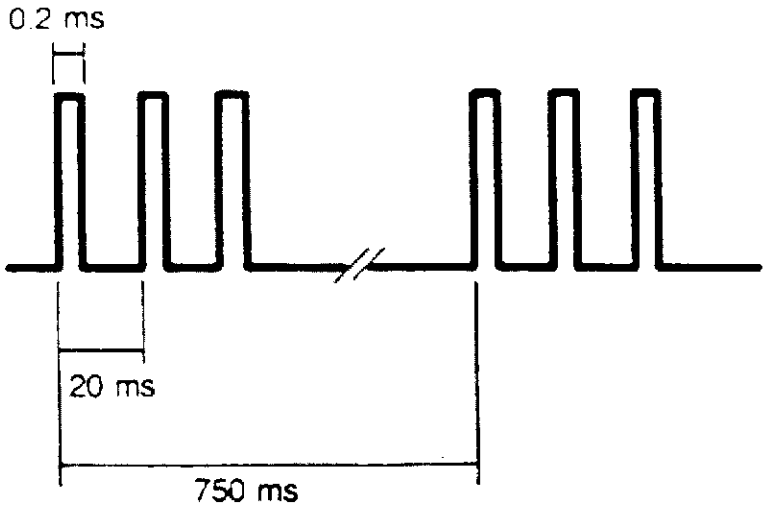

Figure 5 – Double Burst Stimulation Pattern