Microstim Stimulator General Theory

After anaesthesia has been induced with a "sleep drug", it is often necessary for the anaesthetist to administer an additional drug which paralyses all the patient's muscles (with the exception of the heart muscle and the digestive system). Muscle paralysis may be needed to facilitate surgery as well as to aid in the passage of a breathing tube to protect the lungs. The patient is connected to a mechanical ventilator for the duration of the surgery. It is important for the anaesthetist to be able to monitor how long this type of drug lasts so that a top-up dose can be given as necessary during the surgical procedure and also to ensure that the effect of the muscle-paralysing drug has disappeared before the patient is permitted to regain consciousness at the end of surgery. If the muscles are still partially paralysed when the patient awakens, then the patient is unable to breathe adequately. The action of these drugs is to block the normal signal between nerves and muscles so that the muscle will not contract when the nerve is stimulated. The normal electrical activity of a nerve can be imitated by a battery-powered peripheral nerve stimulator. It is a relatively easy matter to stimulate a superficial nerve which lies close to the skin using a small electrical current, and to observe how strongly the muscle contracts. Ordinary EKG-type electrodes are ideal for the purpose so that the entire process is "non-invasive". If the patient is completely paralysed, there will be no muscle contraction in response to nerve stimulation. As the effects of the neuromuscular blocking drug wanes the force of muscle contraction progressively increases.

Principles of operation

The importance of supramaximal stimulation

The Microstim delivers electrical current to a peripheral nerve, typically the ulnar nerve at the wrist; When the peripheral nerve is stimulated sufficiently the muscle fibres contract. Muscles contain many muscle fibres and some are more easily activated than others. When monitoring neuromuscular transmission in the operating room it is important that all the muscle fibres contained within the muscle contract. The higher the current applied to the nerve, the stronger the muscle contraction as more of the muscle fibres are recruited. The current requires to reliably stimulate all the fibres is known as the "supramaximal stimulation current". Once this current has been reached, increasing the current further will not increase the muscle contraction. Nerve stimulators must be capable of delivering supramaximal stimulation regardless of changes in the impedance of the skin overlying the nerve. The current required to elicit supramaximal stimulation in the majority of patients in approximately 60-80 mA. By delivering the same amount of supramaximal stimulation before and after administration of neuromuscular-blocking drugs, the clinician can determine the extent of the neuromuscular block.

The Microstim supramaximal nerve stimulator is battery powered
It is similar to other stimulators in offering four patterns of supramaximal stimulation:
Single Twitch, Train-of-four (TOF), Tetanic, Double Burst.
These techniques produce specific responses or patterns of muscle contraction. The level or type of block is assessed by observing visually or tactilely the degree to which the affected muscle contracts.
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1 Hz:

Consists of a single stimulus applied repetitively at a frequency of 1.0 hertz (Hz). The pulses are typically rectangular and have a duration of 0.2 milliseconds or less to avoid repetitive nerve firing. Single-twitch stimulation is the least sensitive method of demonstrating a partial neuromuscular block. The twitch response is not reduced until at least 75% to 80% of the muscle receptors are blocked, and it disappears

completely when 90% are blocked. A disadvantage of this mode of stimulation is the requirement for a control muscle response before the neuromuscular blocking drug was administered.

Train of Four (TOF):
Consists of four stimuli at 2 Hz: at half-second intervals. During competitive neuromuscular blockade the four muscle twitches fade, so that the second is smaller than the first, and the third is smaller than the second, and so on. The train of four ratio is the ratio of the amplitude of the fourth response in relation to first. The train of four ratio begins to decrease when more than 70% of the receptors are blocked. TOF stimulation can be repeated every 12 seconds. Train of four has the advantage that no control measurement is required, but it has been shown that it is difficult for the observer to detect fade reliably and hence the train of four ratio, unless the actual train of four ratio is less than 0.4

Double-burst:
Consists of two short bursts of pulses with an interval of 0.75 seconds between bursts. Each burst comprises only two or three pulses but the frequency is high (50Hz) so that the muscle responds to each burst with a fused, tetanic twitch. The Micostim delivers 3 pulses at 50Hz followed by a 0.75 second pause, then 2 pulses at 50Hz. The neuromuscular response consists of two short muscle contractions. If there is no significant neuromuscular blockade, the twitches are of equal magnitude. In the presence of partial neuromuscular blockade the second twitch is less forceful than the first. The ratio of these contractile forces (DBS Ratio) indicates the degree of neuromuscular blockade. Double Burst stimulation was designed specifically to be easier for the anaesthetist to use, and it is possible to reliably detect fade when the actual ratio is less than 0.7, giving an advantage over train of four stimulation.

Post Tetanic Count

This mode of stimulation was designed to quantify profound neuromuscular blockade. When a very high proportion of receptors are blocked, the twitch response to train of four stimulation or DBS stimulation is completely ablated. It is still possible to quantify neuromuscular blockade by utilizing the phenomenon of post-tetanic facilitation. During the application of tetanic stimulation, the mobilization of neurotransmitter is increased in the nerve terminal. This enhancement persists for a number of seconds after the cessation of the tetanic stimulation. During the "post-tetanic" period, 1 Hz stimulation of the nerve will elicit enhanced, or "facilitated" twitch responses because a large amount of neurotransmitter has been mobilized ready for release. During profound neuromuscular blockade, provided that there are some unoccupied receptors, the number of facilitated twitches, the Post Tetanic Count, can be used to quantify the degree of blockade. This mode is useful in situations where profound blockade is required, for example during neurosurgery. Tetanic stimulation at 50Hz is applied for 5 seconds, followed by a 3 second pause, then stimulation at 1Hz. The degree of blockade is quantified by counting the number of "facilitated" 1Hz twitch responses.

Application of the stimuli
Motor fibres are stimulated before pain fibres and, as low stimulating currents are used, the patient feels minimal discomfort
Conventional EKG disposable electrodes are most commonly used for applying the stimulation as they provide good contact with low impedance.
Ball Electrodes

Microstim Stimulator General Theory

Some competitor models are equipped with ball electrodes mounted on the stimulator. This method was rejected due to the possibility of varying skin impedance caused by the small to area of application and the conductive properties of the skin . Intermittent conductivity could cause inadvertent large variations in the energy levels being applied.
Burns are unlikely to occur with peripheral nerve stimulators because they use low current and typically only briefly impart electrical energy through the skin.
The Microstim was designed to be battery driven as this eliminates many of the perceived risks in relation to burns particularly with earth leakage currents and alternative paths via electrosurgical units

Microstim Specifications
Typical current mA into 1000 ohms
Pulse width
Pulse Indicator LED
Battery type MN1604 9volt
Battery state indicator 3 colour LED
Batterty capacity
Height
Width
Depth
Weight gms oz

Terminal polarity indication:
Indicates the positive and negative bipolar electrodes.
Leads comply with FDA "protected" lead set requirements

Pacemakers
Problems have been rarely reported with use of peripheral nerve stimulators during surgical procedures. Eg cardiac pacemaker during surgery. Pacemaker function returned to normal upon cessation of peripheral nerve stimulation. Suitable warnings are given in the instructions.

Associated Publications

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Myirea KC, Hameroff SR, Calkins JM, et al. Evaluation of peripheral nerve stimulators and relationship to possible errors in assessing neuromuscular blockade. *Anesthesiology* 1984 May;60(5):464-6.
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Sansome AJ, de Courcy JG. A new dual function nerve stimulator. *Anaesthesia* 1989 June;44(6):494-7.
Weiner RL. The future of peripheral nerve neurostimulation. *Neurol Res* 2000 Apr;22(3):299-304.

Existing International Standards

Blue Cross and Blue Shield Association. Electrical nerve stimulation [technology assessment report]. 1988
International Electrotechnical Commission. Medical electrical equipment — part 1: general requirements for safety [standard]. IEC 60601-1 (1988-12). 1988.
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