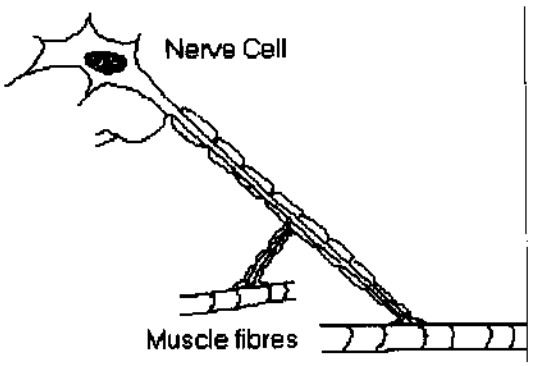
NERVE STIMULATORS

A very simple introduction to the art and science of nerve stimulators

How do nerves work?

Nerves carry messages from the brain to the muscles. They also carry messages from sensors back to the brain. They are the 'wires' of the body.



Nerves are like an elongated bag of salty water. The outside of the nerve is positively charged. In other words it is polarised. That charge is lost when the top end of a nerve cell is stimulated. This is called depolarisation. The wave of depolarisation runs down the cell from the brain to the muscle.

The nerve swells out near the muscle at the 'neuro-muscular junction'. The nerves cell releases a special chemical called Acetyl-choline into the gap between the nerve and the muscle.

How do muscles work?

Muscles have a polarised membrane surrounding them that is very similar to nerves. There are special receptors built into this membrane. When Acetyl-choline attaches to a receptor the membrane is depolarised. The wave of depolarisation runs over the muscle fibre and causes it to contract.

How do muscle relaxants work?

Anaesthetists use muscle relaxants to keep patients from moving during delicate surgery. Relaxants are also used when we need to take over a patient's breathing or when the muscles of the abdomen need to be relaxed to help the surgeon. The muscle relaxants block the receptors on the muscle. The Acetyl-choline released by the nerve terminal can no longer cause depolarisation of the muscle membrane.

How do nerve stimulators work?

A nerve stimulator supplies electrons to depolarise a nerve. The number of electrons supplied per stimulus equals the current. To make sure that the nerve is completely depolarised we keep winding up the stimulating current until the muscular response does not increase any more, then we add another 10%. This is called the supra-maximal stimulus. At this point we assume that the nerve supplying the muscle is completely depolarised. As a result the muscle must be maximally stimulated by the nerve. The muscle contraction that results must also be maximal. (The contraction is also called a twitch). The muscle response to the stimulus is called a twitch. The amount or strength of movement is called the twitch height. (From the height of the trace on a recorder.) To allow comparison of twitches it is essential that this current remains constant to ensure

the nerve is always completely depolarised.

Placement of electrodes

The outside of a 'resting' the nerve is charged positive. It is 'polarised'. If you add negative electrons to the outside they will neutralise the charge. This will cause that wave of depolarisation to wash down the nerve. The negative electrode should be attached as near as possible to a nerve, commonly the ulnar nerve at the wrist or the elbow. (You can use the facial nerve if you can't get at the hands.) The other electrode can be placed anywhere else along the line of the nerve, commonly half way along the forearm.

The anaesthetist then assesses the amount or strength of movement in muscles supplied by that nerve, usually the thumb.

Types of Nerve Stimulator

Changing resistance

The connection between the electrodes and the skin is not constant.
If the electrodes dry out or come a bit loose from the skin their resistance will increase. There are two ways a nerve stimulator can respond to this change...with a constant voltage or a constant current. Electrical engineers give us the equation: **Voltage = Current X Resistance**

Constant Voltage Nerve Stimulators

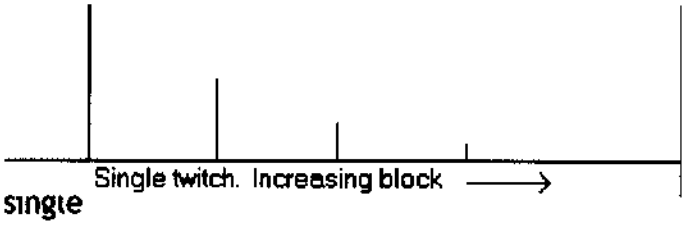
Constant voltage nerve stimulators are relatively easy and cheap to make. Unfortunately if the voltage remains constant when resistance increases then the current must decrease. As a result the nerve may not be completely stimulated. The muscle contraction will then be depressed. The anaesthetist will falsely think that the neuromuscular blocking drug is still working. This can be dangerous if the patient moves during a delicate phase of surgery.
Some constant voltage nerve stimulators will display the current actually delivered and will alarm if it falls below some predefined threshold.

Constant Current Nerve Stimulators

Constant current nerve stimulators are the safest but also the most expensive to build. As the resistance of the electrodes goes up they compensate by increasing their voltage. As a result the current stays constant. The stimulation of the nerve remains constant. Any change in response is occurring at the neuromuscular junction or in the muscle itself. There is a limit to how high the nerve stimulator can raise the voltage. At this point the stimulator should give an audible and visual alarm that the stimulating current has not been reached.

Types of Stimulus

1. Single twitch



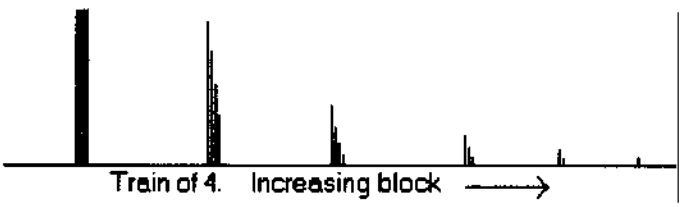
single twitch. A fixed current is used to stimulate the nerve for a brief period of time. This is known as a square wave stimulus. If more than 80% of the receptors are blocked then there will be a decrease in the height of the twitch or no twitch at all.

The amount of movement in response to a supra maximal stimulus **before** any relaxant is given is known as the 'Control Twitch Height. Successive twitches are often reported as a percentage of this control height. eg. a patient can have his neuromuscular blocking drugs reversed when his first twitch reaches 20% of control.

There are 2 problems here:

- You need a control twitch measured before any relaxant has been given. This means winding up the nerve stimulator to supra maximal and then measuring the response. In emergency cases you have to give the relaxant as soon as the patient is asleep. You would have to do the calibration on the patient while they were awake. This can be quite unpleasant.
- The second problem is you have to remember how high the first twitch was. This is not possible unless you are using expensive equipment to actually measure the twitch.

2. Train of four



To help overcome the problem of forgetting the control height the 'Train of 4' was developed. Four twitches are given at 1/2 second intervals. The first twitch in the train can be used as a control. Each successive twitch becomes lower as the Acetyl choline in the nerve terminal is depleted. After a pause of 30 seconds the Acetyl choline in the nerve terminal will have built up again so the test can be repeated.

As well as estimating the 'fade' of twitches in the 'Train of 4' it is also useful to simply count the twitches. Fewer stimuli make it across the neuromuscular junction as the block becomes deeper. For most general surgery a block down to 2 twitches is adequate.

When only one twitch is visible the patient may still be able to move slightly. If you give relaxant until no twitches are visible you no longer whether you are giving a little bit to much or a lot too much. 3. Post Tetanic Count The post tetanic count was developed to allow the control of deep blockade. After a period of rapid stimulation (tetany) the nerve cells 'gear up' for action. After a brief pause the twitch height will be increased above baseline for that degree of block.

This example shows the train of 4 at the same depth of block before and after

tetany. Notice that not only is the height of the twitches increased but also the number of twitches.

This is the way post tetanic count is used. Relaxant is gradually given until no twitches at all are visible. Then a burst of tetany is given, a pause, then one twitch every second for 10 seconds. The anaesthetist simply counts how many twitches are visible. When only 1 or 2 twitches are visible the block is deep enough for virtually any surgery.

4. Double burst stimulation

At the other end of the relaxant scale the anaesthetist may need to ensure that the neuromuscular block has worn off. Fade in the train of 4 can be difficult to detect in minor block. The middle 2 twitches make it difficult to compare the first and the last. Double burst stimulation consists of two sets of twitches that are separated by a brief interval to improve perception of fade. (The first twitches and the brief pause are designed to prevent facilitation occurring between the first and second burst.)

5. Where to from here?

Why not visit Life-Tech, Inc. they have a complete range of nerve stimulating hardware (and a really nice web site!)

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