

Question What is Nerve Mapping and how does it work?

Answer Nerve mapping is a technique whereby superficial peripheral nerves can be traced and located **transcutaneously** for peripheral nerve blocks during regional anesthesia procedures. The technique enables the anesthesiologist to determine the site for needle insertion prior to puncturing the skin.

Explanation The current density radiates outward from the nerve mapping pen in a spherical form. There is also a decrease in behavioral density as the distance is increased from the source. Axons with a larger diameter exhibit a lower activation threshold than small axons. This results in electrical stimulation activating larger axons first before activating the smaller axons. Looking at the behavioral density, most of the axons will be activated close to the probe, whereas only the larger diameter axons will be activated further away from the probe. There are two options to increase the energy delivered to a nerve without changing the distance from the electrode - increase the current amplitude and/or increase the pulse width.



Question If a neuromuscular response is not achieved for the specific Nerve Mapping Probe position should one rather increase the Current Amplitude, or the Pulse Width?

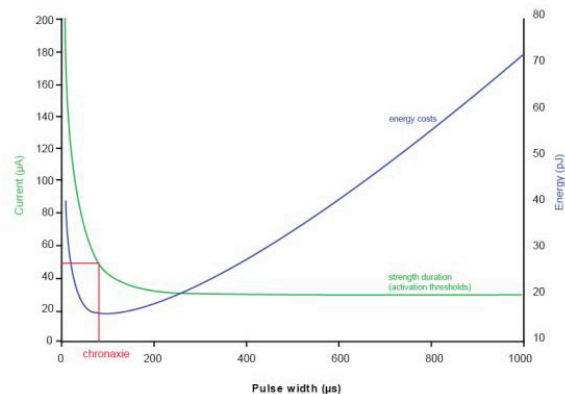
Answer There is an optimal **Pulse Width** at which a specific nerve is most excitable. This is called the **chronaxie** threshold. It is preferable to keep the pulse width as close to this value for the related nerve or nerve plexus, as the Peripheral Nerve Stimulator allows, then increase only the current.

Explanation It should be noted that, although there are many published values for chronaxie for various excitable tissues, the range of variability for a given tissue type is quite large. It is generally assumed, however, that nerves can be classified according to their **chronaxie thresholds** as follows:

Classification	Chronaxie	Sensory Functions
A (alpha)	40-100 μ s	Predominantly motor neurons they also have the following sensory functions: Proprioception, hair receptors, vibratory sensors, high discrimination touch
A (delta)	150 μ s	Deep pressure and touch, pricking pain, cold
C	400 μ s	Crude touch and pressure, tickle, aching pain, cold, warmth

From the above table it would seem reasonable to deduce that the ideal **pulse width** to facilitate a motor nerve response (A alpha), would be around 100 μ s. If one sets the nerve stimulator at 100 μ s and increase the amplitude to 5mA giving a total charge of 500nC one would not get the same muscle response as if the setting is at 500 μ s and 1mA, also giving a total charge of 500nC. In the second case even though the total charge transferred to the nerve is the same, because of the **chronaxie threshold** of 100 μ s for the nerve, much of the energy transferred to the nerve after the 100 μ s is wasted on the nerve.

This is clearly shown by this graph. The **strength duration curve** (green) indicates the current necessary at the different pulse widths to facilitate a contraction. The energy cost or **total charge** is shown by the blue curve. It can be seen that the stimulation is most energy efficient at the **chronaxie** pulse of +/- 80µs width as would be expected. It should be noted how the energy cost increases when pulse width increases.



Application As a preference, keep the nerve stimulator at a 100µs pulse width and adjust the current. If the nerve stimulator is already set at 20mA and the Nerve Mapping Probe does not elicit any neuromuscular response, increasing the pulse width to 300µs will offer 3 x more charge, however bear in mind that the net effect on the nerve will not constitute a contraction which is 3 times more powerful.

Question What are the **advantages** of Nerve Mapping?

Answer Due to the fact that the **surface location** of the nerve is pre-determined and thus the optimal entry point for the needle, the technique reduces the need for multiple needle insertions and discomfort to the patient. It also **reduces the time** to perform the peripheral regional nerve block.

Question For which Peripheral Regional Nerve Block procedures are Nerve Mapping techniques appropriate?

Answer The nerve mapping technique may be used for various approaches to the **brachial plexus**, as well as the **axillary, musculo-cutaneous, ulnar, median and radial nerve blocks** of the upper limb; and the **femoral, sciatic and popliteal** nerve blocks in the lower limb. Surface nerve mapping is particular useful where **classic anatomical landmarks are absent** or difficult to define, for example in children with contractures (arthrogryposis multiplex congenital; burns) or with major congenital limb defects.

Question What is Coulomb's Law and how does it apply to Nerve Mapping?

Answer It relates the **charge intensity** necessary to elicit a **neuromuscular response** to the distance between the probe and the nerve.

Explanation In order for **nerve excitation** to take place, the energy delivered to the nerve must be high enough to trigger the **threshold voltage**. The current-distance relationship is governed by Coulomb's Law:

$$E = K(Q/r^2)$$

where E is the energy required, K is a constant, Q is the minimum current and r is the distance away from the electrode.

The equation shows what effect the distance has on the energy delivered
 $\therefore 2 \times \text{Distance} = \frac{1}{4} \text{ Energy}$

The equation also shows how you need to increase the current as your distance increases

$$\therefore 2 \times \text{Distance} = 4 \times \text{Current}$$

Question How is the STIMPOD peripheral nerve stimulator unique with regards to implementing Nerve Mapping techniques?

Answer The STIMPOD peripheral nerve stimulator allows the user to use the needle and probe simultaneously, eliminating the need to change cables or make markings on the patient.

Explanation The practical application of nerve mapping as a technique has always been a cumbersome technique. In order to use nerve mapping effectively, the position and angle of the probe must be recorded exactly before inserting the needle. Marking the probe position with a marker has proved unsuccessful and

cumbersome, as this does not capture the exact position and angle relating to subcutaneous structures - i.e. bone structure, muscles etc. It is important to have the ability to keep the probe in its original position when inserting the needle.



This will ensure exact positioning and angle of the needle. The STIMPOD peripheral nerve stimulator facilitates this procedure by providing a combined Nerve Mapping/Locating cable. The unit will automatically switch between the probe and the needle, depending on which device is in contact with the skin. The STIMPOD will guide you through the entire procedure, switching between the probe and the needle as needed whilst keeping an eye out for high impedance and nerve proximity.

Question Can an approximation be made with regards to current strength versus distance of the nerve?

Answer Yes, the following approximation can be made concerning depth penetration. (Pulse width of 200µs and more in patients of normal weight)

5mA = **1-2cm depth penetration**

20mA = **3-4cm depth penetration**

However, these approximations are highly dependent on the impedance structure of the surrounding tissue.

Explanation These are only approximations as the impedance structures of the surrounding tissue are very complex and differ from area to area. Obese patients can render the nerve mapping technique useless if your nerve stimulator does not have the option to significantly increase the current due to higher than normal impedance levels in the surrounding tissue.

The tip design also influences the current density, and as a result will influence the depth penetration of the probe. The current density is defined as the current applied over a specific area. The area is directly related to the radius of the tip and the part of the tip that is in contact with the skin. In the case of the larger tip, this area is significantly more than with the smaller tip. Because current density decreases as the distance from the source increases, the smaller tip will be able to activate far more axons than the larger tip at the same depth beneath the skin.

References

- 1] Geddes LA. Accuracy Limitations of chronaxie values. IEEE Trans Biomed Eng. 2004 Jan; S1(1):176-81



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