PERIPHERAL NERVE LOCATOR

Summary Paraesthesias are the traditional sign of successful nerve localization, but the use of electrical stimulation has gained popularity with the advent of improved equipment. A low current electrical impulse applied to a peripheral nerve produces stimulation of motor fibres and identifies the proximity of the nerve without actual contact or patient discomfort. Its use may reduce the chance of nerve injury.

Keywords Nerve locator, Rheobase, Chronaxy

Introduction

In recent years, the use of nerve stimulators has moved from the status of occasionally used device to one of common use. The emphasis on techniques that employ multiple injections near individual nerves or placement of stimulating catheters has provided impetus for this change.

In 1912, Von Perthes became the first to describe the technique of peripheral nerve stimulation for various nerve blocks[1].

Nerve locators are the devices used to locate a nerve fibre or bundle in order to administer a local anaesthetic to a local area. These devices send a small electrical impulse, via a drug-administering needle to nerve fibre or bundle in order to locate the required nerve to be blocked. This technique identifies the proximity of nerve to the nerve locating needle without actual contact so its use may reduces the need to elicit paraesthesia and reduce the chance of nerve injury and is better tolerated by patients[2].

The use of nerve stimulator is not a substitute for complete knowledge of anatomy and careful site selection for needle insertion[3].

Electrophysiology Of Nerve Locator[1, 4, 5]

In 1950, Von Helmholz in a classic series of experiments with an isolated nerve-muscle preparation demonstrated the temporal nature of nerve fiber conduction. There is a threshold stimulus that must be applied to a nerve fibre to cause it to propagate a nerve impulse. Below this threshold, no impulse is propagated. The stimulus that initiates the depolarization can be the electrical current. Depolarization of nerve fibre leads to an action potential, which, depending on its type gives rise to a sensory perception or muscular contraction. If a square pulse of current is used to stimulate the nerve, the total charge applied to the nerve is the product of the current (strength) and the length of the pulse (duration).

The least intensity of direct current that can initiate an action potential when applied to a nerve fibre for an infinite period is known as the **Rheobase (Ir).** Similarly, the duration of application of an electrical stimulus is also an important factor. **Chronaxy (C)** is the minimum time in which an action potential is initiated when a direct current twice the intensity of the rheobase is applied. The intensity of direct current that initiates an action potential where applied to a given nerve fibre is expressed as

$\mathbf{I_m = I_r (1 + C/t)}$ where $\mathbf{I_r}$ is the rheobase
C is the chronaxy
t is the time
$\mathbf{I_m}$ is the minimum intensity

The chronoxy has a specific value for each type of nerve fibre. Schematically it is inversely proportional to the degree of myelination of the nerve fibre. Thus the greater the myelination, the less is the minimal intensity for initiating an action potential.

As the sensory fibres are less myelinated than the motor fibres, their chronaxie is higher. Therefore, by calibrating the nerve stimulator, one can selectively stimulate the larger A alfa motor fibres without stimulating small A delta or C fibres (thereby producing muscle contraction). In practical terms, this means that a mixed peripheral nerve can be located by a twitch in the muscle it supplies without causing pain.

In practice, the nerve stimulator is not in contact with but, rather, at a slight distance from the nerve fibre, Coulomb's law states that the intensity of electrical current is inversely proportional to the square of the radius, i.e. $I_t = k\ (I/r^2)$ where I_t is the electrical current at a distance r from electric source, k is a constant that depends of the electrical properties of tissues traversed by the current and I is the intensity of the electric source. The presence of Inverse Square means that a very high stimulus is needed once the tip is some distance away from the nerve. This can be of clinical concern, because stimulation of the nerve more than 2 cm can require currents in the region of 50mA (depending on pulse width) and currents smaller than this have been reported to cause ventricular fibrillation when applied directly to the heart (so called micro shock) so appropriate care should be taken in any patient who may have intracardiac electrodes (e.g., pacemaker, Swan Ganz catheter)

The localization of a nerve by an electrical stimulation is based on these principles of physics. The nerve stimulator that generates electric current is connected to a conductive needle, the tip of which acts as a cathode. The intensity of current to be used should be carefully determined in order to produce nerve stimulation, that is, muscle contractions (and very rarely, paraesthesias).

At an appropriate distance from the nerve, the current should preferably be injected into the perineuro-vascular sheath, which surrounds the nerve, but is at a safe distance from the perineurium so as not to locerate the nerve. The ideal distance is 1 mm from the perineurium into which a direct current of 0.5 -1.5mA intensity applied for 50-100μs will initiate an action potential in the motor fibres. One should take into account only the muscle contraction produced by the stimulation of the nerve and should ignore muscle contractions in the vicinity of the needle which occur mainly due to a direct stimulation of he muscle.

Desirable Characteristics Of Peripheral nerve locator[3, 4,6,7]

1. Constant current output: The intensity of current should be constant and independent of the resistance of different tissues, which may vary from 1 to 20KΩ. Thus, the internal resistance of the current generator should be high so that the resistance offered by different tissues does not change the intensity of current that reaches the nerve trunk.
2. The current delivered should be displayed on a clear reading meter, preferably digital.
3. The polarities of the terminals should be clearly marked, as peripheral nerves are most effectively stimulated using needle as cathode (negative terminal)
4. It should allow between 0.1-and10 mA of current in pulses lasting 100 to 300 msec at a frequency of 1 to 10 Hz.
5. The device should have both high and low out puts (Dual mode). This is especially important if the instrument is also used for monitoring n-m block for which the high currents required are best provided by a separate output.
6. There should be an indicator, either visual or auditory (or both) that appears when the stimulator is activated.
7. A battery indicator should also be provided.
8. The connector should be made of high quality, alligator type clip of low resistance.

To ensure a safe and successful nerve block, it is important for the operator to be aware of the design limitation and the degree of inaccuracy in the stimulator being used.

Choice of Needle

The insulated needles permit very precise localization of nerve with very feeble current intensity. But disadvantages are, such needles are expensive, often unobtainable and can alter feel of the tissues. Despite these, because these needles considerably increase safety (especially in a child and particularly when the patient is under light general anaesthesia) they should be definitely preferred.

The disposable insulated needle come with a flexible and transparent extension tubing attached to short beveled metallic needle, which, in turn is covered by an insulating material, such as Teflon or plastic, except for the very tip of the needle where the metal is exposed the needle is connected to an insulated metallic cable.

Procedure for the use of PNS for nerve location

The nerve locator should be systematically tested prior to each use. All normal sterile protocols must be followed. The skin electrode (anode) should be placed at a site remote from the site of stimulation by connecting the lead to a common ECG electrode. It is preferable that the current not pass through the heart on its way to the skin electrode. The syringe containing the local anaesthetic is attached to an extension set. The other end of extension set is connected to a 22G,a short bevel, and insulated nerve stimulator needle. After identifying the landmarks for the block to be performed, the needle is inserted through the skin. The exploring electrode (cathode) is connected to the hub of needle via alligator clamp. The nerve locator is switched on. The intensity of current should be higher at the beginning and set at 4 or 5 mA at a frequency of 1 Hz. The needle is advanced slowly, while observing for the relevant muscle movements. Once the muscle contractions occur, the current is gradually reduced and the needle is moved deeper to find maximal contractions. This process is continued until a point is reached where there are maximal muscle contractions with minimal current (0.5mA or less). If the nerve is not easily located, the needle should be systematically redirected in a " fan" across the expected path of the nerve. After careful aspiration, 1 to 2 ml of local anaesthetic agent is injected through the needle, which should result in cessation of muscle activity within few seconds. Persistence of the twitch may indicate that the nerve is separated from the needle by a thin tissue membrane that conducts current easily but prevents local anaesthetic from reaching the nerve. The needle should be advanced further and the test dose is repeated. Immediately after muscle movements have ceased, the remaining anaesthetic solution should be injected through the needle in single shot technique. If continuous catheter technique is planned then no bolus injection is made, rather a catheter is advanced through the needle by stimulating or non-stimulating catheter technique[3].

Localization of purely sensory nerves such as Lateral cutaneous nerve of thigh can be accomplished by eliciting pulsating paraesthesias with the stimulator[1].

The calibration of current intensity is very important; if the intensity is too feeble, there is risk of injury to the nerve. If the intensity is too high, the nerve may be stimulated even if the needlepoint is still outside the perineural sheath.

Advantages

1. The nerve localization by PNS can be used for nearly all-common blocks.
2. There is no need to produce paraesthesia and reduce the chance of nerve injury and is better tolerated by patients.
3. Less local anaesthetic can be used with this technique since the required nerve can be more accurately found.

4. This technique is especially useful in less reliable landmarks,such as psoas compartment or obturator foramen, which require either large volume of local anaesthetic or the establishmemt of a distinct localization of desired nerve to provide adequate anaesthesia[2].
5. Patient co-operation is unnecessary and technique can be used in patients who are compromised because of injury, alcoholic intoxication, drugs, or medications. It also enables painful nerve blocks to be performed in anaesthetized individuals, which is often the case in paediatric practice.

6.If peripheral nerve stimulator has dual function it can be used for neuro -muscular monitoring as well as to locate nerves during regional anesthesia.

7.They are a useful teaching aid.

There are many case reports on various nerve blocks performed using nerve locator showing that it is method of choice for many practitioners and success rates greater than 90%[3].

Disadvantages

1. The primary impediment to successful use of nerve stimulator in a clinical practice is that it is at least a three-handed, or two individual technique, although there are devices that allow foot control of the stimulator current.
2. It is possible to stimulate the nerve when the needle tip is still some distance away if the current used is too high.
3. It is not possible to stimulate sensory nerves in the same way as those with a motor component.
4. There is some cost associated with purchasing and maintaining a nerve stimulator, and the various disposable components required.

References

1. Text Book Of Regional Anaesthesia; Prithvi Raj P, Church chill Livingstone, 2002.
2. Barash PG, Cullen BF, Stoelting RK.Clinical anaesthesia, 5th edition; Lippencott Williams and Wilkins, 2006.
3. David.L.Brown, Atlas of Regional Anaesthesia, 3rd Edition, Elsevier Saunders, 2006.
4. Regional Anaesthesia in infants, Children, and Adolescents, Bernard J.Dalens, 1st edition, Williams & Wilkins, 1993
5. Ford DJ, Pither CE, Raj PP: Electrical characteristics of peripheral nerve stimulators: Implications for nerve localization. Reg Anesth 9: 73-77,1984.
6. Galindo A: Electrical localization of peripheral nerves: Instrumentation and clinical experience.Reg Anesth 8:49-50,1983
7. Wildsmith JAW, Armitage EN, Mcclure JH. Principles and Practice of Regional Anaesthesia, 3rd Edition, Churchchill Livingstone, 2003.