Electrical nerve stimulation as an aid to the placement of a brachial plexus block

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ABSTRACT

Most local anaesthetic blocks are placed blindly, based on a sound knowledge of anatomy. Very often the relationship between the site of deposition of local anaesthetic and the nerve to be blocked is unknown. Large motor neurons may be stimulated with the aid of an electrical current. By observing for muscle twitches, through electrical stimulation of the nerve, a needle can be positioned extremely close to the nerve. The accuracy of local anaesthetic blocks can be improved by this technique. By using the lowest possible current a needle could be positioned with in 2–5 mm of a nerve. The correct duration of stimulation ensures that stimulation of sensory nerves does not occur. The use of electrical nerve stimulation in veterinary medicine is a novel technique that requires further evaluation.

Key words: brachial plexus, canine, local anaesthesia, nerve blocks, nerve mapping, nerve stimulation.

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INTRODUCTION

Local anaesthetic blocks are commonly used to provide peri-operative analgesia but are also utilised for diagnostic and therapeutic procedures. Local anaesthetic blocks are increasingly used as part of a balanced anaesthetic protocol due to their ability to attenuate the surgical stress response and decrease anaesthetic requirements[6,7,10,13]. With our increased knowledge of neuroplasticity in response to pain and the phenomena of 'winding up', local anaesthetic agents offer interesting possibilities in attenuating this response[1,2,12] and therefore local anaesthetic blocks may form an important part of pre-emptive analgesic plans[7].

The techniques for local anaesthetic blocks are based on an explicit knowledge of anatomical structures and their location. Most techniques use a blind approach and may fail when anatomical structures have been disturbed due to injury or normal biological variation. Poor knowledge of anatomical structures leads to misplacement of the needle and the injection of the local anaesthetic at an inappropriate site. Large volumes of local anaesthetic are administered in order to allow for the diffusion of the local anaesthetic through the tissues into the nerve. Local anaesthetics are toxic and high doses may lead to side-effects.

In order to improve the accuracy of local anaesthetic blocks in unconscious or uncooperative humans, electrical nerve stimulation has been utilised to identify structures. A small electrical charge that disseminates from the tip of a hypodermic needle is used to stimulate motor neurons. By observing the associated muscle twitches, one is able to identify the nerve to which the needle is closest. The smaller the charge used the closer the needle will have to be to the structure in order to obtain an associated response. By being able to accurately identify nerve structures, the local anaesthetic can be deposited close to the nerve thus increasing success rates and reducing the quantity of local anaesthetic required.

The brachial plexus block is used to desensitise the branches of the brachial plexus that supply the forelimb in order to provide analgesia. The block is particularly effective in desensitising the forelimb from the elbow distally and should be performed for repair of radial and ulnar fractures and foot surgery[13]. The major branches of the brachial plexus are the musculocutaneous, radial, median and ulnar nerves[12,13]. The approach to the brachial plexus is blind and based on standard anatomical position[12,13]. Complications associated with the performance of a brachial plexus block include pneumothorax, arterial or venous puncture, haemothorax and infection[13]. This case study describes the utilisation of electrical nerve stimulation to perform a brachial plexus block.

CASE HISTORY

A 6.5-kg, 2-yr-old male Jack Russell terrier with a left midshaft radius/ulna fracture following a motor vehicle accident was presented for surgery. The patient had been admitted 3 days prior to surgery and was in a stable condition in the intensive care unit.

The Jack Russell was premedicated subcutaneously with 0.01 mg/kg acepromazine (ACP 2, Centaur Labs, Bryanston) and 0.4 mg/kg morphine (Morphine, IntraMed, Port Elizabeth). Anaesthesia was then induced intravenously with thiopentone (Thiopentone Sodium, IntraMed, Port Elizabeth) until the jaw tone was sufficiently relaxed to allow intubation. After endotracheal intubation, the patient was attached to a small animal anaesthetic machine and halothane (Fluothane, Astra-Zeneca, Sunninghill) was administered to maintain the patient in Stage 3, plane 2 of anaesthesia. Amoxicillin (Amoxil 500, Smithkline Beecham, Isando) was administered intravenously at 20 mg/kg.

The skin overlying the point of the shoulder was shaved and aseptically prepared. A 20 G, 150 mm polyvinyl-sheathed needle (Locoplex, Vygon, Gloucestershire, UK) was inserted at the point of the shoulder. The nerve stimulator (Plexival, Vygon, Gloucestershire, UK) negative electrode was attached to the needle and the positive electrode was placed on the scapula. The nerve stimulator was set initially at a frequency of 2 Hz, an impulse duration of 50 μs and the current to 90 mA. The needle was slowly advanced medially to the scapula in the direction of the 8th intercostal space. The limb was then observed for muscle twitches.

As the needle approached the musculocutaneous nerve the muscles cranial to the shoulder twitched. The current was reduced as the twitches increased as the nerve was approached. The current was

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reduced from 90 mA to 5 mA. The needle was then directed more caudally to locate the next branch of the brachial plexus. By redirecting the needle and keeping the current flow low the position of the next branch of the brachial plexus could be determined. The procedure was repeated until all the branches of the brachial plexus (median, radial and ulnar nerves) had been located. As each nerve was identified, 1 mℓ of 5 mg/mℓ bupivacaine (Macaine, Adcock Ingram, Midrand) was deposited at the nerve.

The patient remained stable throughout the anaesthetic period. Heart rate varied between 80 and 112 bpm, respiratory rate between 28 and 45 bpm, pulse oximetry between 91 and 98 % and the anaesthetic plane was maintained in Stage 3, plane 2. No adverse effects were observed during the anaesthetic period or during the postoperative period.

DISCUSSION

The efficacy of this block is difficult to assess, as no verbal communication with the patient is possible. If the patient appears relaxed postoperatively with no behavioral patterns associated with pain as have been described, then it is assumed that the block was effective[5]. Pain scoring tables for the assessment of pain have been described but currently no perfect scoring systems exist[7,8,11]. Visual analog scales are very useful[14].

As the block is usually placed blindly, the association between nerve structures and the placement of local anaesthetic agent is largely unknown. Large volumes of local anaesthetic are usually used to ensure the efficacy of the block[3]. Electrical nerve stimulation is particularly useful as it enables us to identify this relationship more closely[3]. It is therefore more likely that the block will succeed and be more effective[3].

The charge delivered by a nerve stimulator is directly proportional to the current and the duration of application. In order to stimulate a nerve, a certain minimum current is required regardless of the duration of pulse application[9]. Larger nerves are more easily stimulated and require a short duration of current application[9]. This makes it possible to stimulate a large alpha motor neuron without stimulating smaller alpha delta and C-type neurons[9]. In practice this means that a muscle twitch can be stimulated and produced without causing any pain[9]. Motor neurons are usually stimulated with a charge applied for 50–100 μs, alpha-delta fibres at 150 μs and C fibres at 400 μs[9]. Pure sensory nerves usually require a duration of 300–1000 μs for stimulation to occur[9].

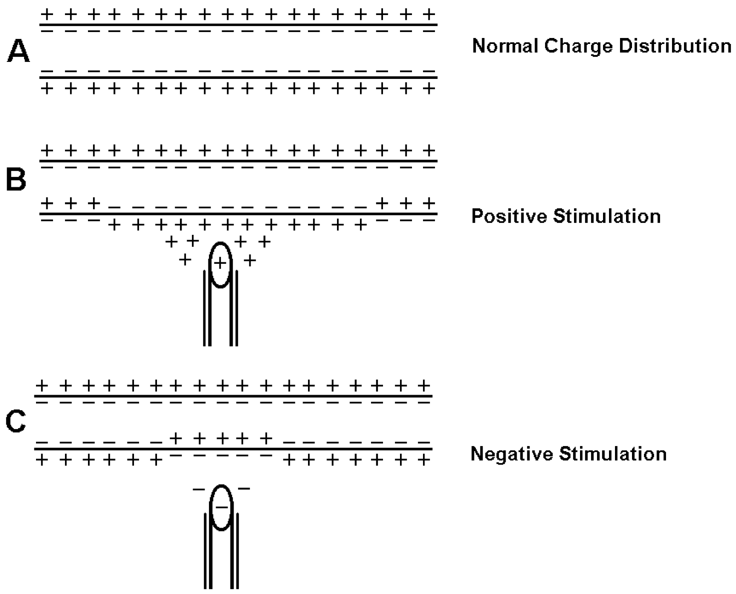

Fig. 1: **Effect of charge on the stimulation of nerves.** (A) **shows the normal charge distribution on a nerve. With positive charge stimulation of a nerve** (B) **an area of hyperpolarisation is produced adjacent to the nerve and nerve conduction starts distant to the site of stimulation. Negative charge stimulation** (C) **results in depolarisation of the nerve at the point of stimulation.**

Current dissipates over distance and this relationship between the nerve and the stimulator's needle is defined by Coulomb's Law[9]. Coulomb's law states that if the distance between 2 points is doubled there is a 4-fold reduction in force[4]. For electrical nerve stimulation it means that a higher current setting is required the further the needle is from the nerve. It is also known that less charge is required when the negative electrode is utilised to stimulate the nerve[4]. The negative current flow adjacent to the nerve produces depolarisation of the nerve and hence nerve conduction[4]. This results in a more correct physiological stimulation of the nerve. A positive electrode adjacent to a nerve results in an area of hyperpolarisation and more distally an area of depolarisation where nerve conduction starts in an area distant from the area of stimulation[4](Fig. 1). Charges in excess of 40 mA may result in microshock if applied directly to the heart[4].

Owing to the relationship between distance and current, advancing the needle closer to a nerve produces a greater increase in muscle twitch response than a doubling of the current[9]. A small current enables us to identify nerves very accurately[9].

An insulated needle is used during the identification of nerve structures. A non-insulated needle dissipates its current over the entire length of the needle. Should the shaft of such a needle pass close to a nerve it will result in stimulation, leading to a false identification of nerve structures in relation to the point of the needle[9]. Charge dissipation occurs in an ellipsoid pattern, resulting in a large surface area over which the charge is distributed. This increases the amount of charge required for nerve stimulation and reduces the accuracy of needle placement[9]. An insulated needle results in the dissipation of charge only from the point of the needle and a more spherical distribution of charge. With an insulated needle, the needle can be positioned 2–5 mm from the nerve[9] (Fig. 2). This reduces the amount of charge required for nerve stimulation and enables a more accurate identification of the nerves. For this reason a sheathed needle should be used.

In humans, this technique may be

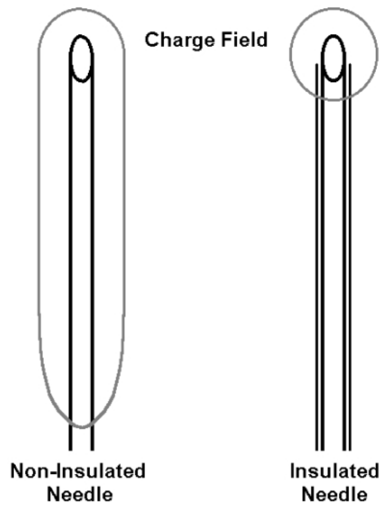

Fig. 2: **Charge distribution from an insulated and non-insulated needle. The non-insulated needle produces a large charge field enabling the stimulation of the nerve beneath the shaft of the needle. An insulated needle provides a small charge field enabling a more accurate placement of the needle.**

employed to block purely sensory nerves. The duration of charge is increased and the patient is asked to respond to a radiating paraesthesia induced by the nerve stimulator[9]. The local anaesthetic block may be tested by stimulating the nerve after local anaesthetic has been injected and no paraesthesia should be felt[9].

Redirection of the needle may result in nerve damage and neurological dysfunction after the placement of a nerve block. The use of electrical nerve stimulation may enable in the multiple repositioning of the needle around the nerves. In a study investigating multiple injection techniques, no difference in neurological complications were observed between single and multiple placement techniques[3].

The large volume of local anaesthetic agents usually used in the placement of local anaesthetic blocks predisposes the patient to risks of systemic toxicity[3]. Systemic complications in relation to local anaesthetic use have been reported to occur at a rate of 3.9–11 per 10 000 local anaesthetic blocks in humans[3]. Systemic toxicity occurs as a result of peak serum concentrations of the local anaesthetic agent[13]. The initial signs of toxicity involve the central nervous system and include seizures and central nervous system depression followed by hypotension and cardiovascular collapse[13]. The toxic dose of lignocaine in dogs is 20 mg/kg[13]. With the use of a nerve stimulator, a success rate of 94 % was obtained using volumes of local anaesthetic less than the recommended quantities[3].

CONCLUSIONS

Electrical nerve stimulation offers the advantage of producing a greater success rate of local anaesthetic blocks and a reduction in the volume of local anaesthetic used. Electrical nerve stimulation may be a useful technique in teaching students to perform local anaesthetic blocks. It brings the reality of nerve innervation to life through the observation of the associated muscle activity. It enables the inexperienced anaesthetist to gain confidence in performing these techniques. In time, this technique may allow the development of new local anaesthetic techniques at sites where nerves follow less consistent anatomical pathways.

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