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Electrophysiological effect of injectates on peripheral nerve stimulation

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Introduction: Despite years of clinical use of nerve stimulation, the electrophysiological effect of injectates on nerve conduction using peripheral nerve stimulation remains unanswered. The observation that a small volume of local anesthetic or normal saline abolishes the muscle twitch induced by low current (0.5mA) has been reported. It has been suggested that the mechanism underlying this phenomenon is due to physical displacement of the nerve. This explanation has been generally accepted by most anesthesiologists and textbooks. However, we hypothesize that the mechanism of this phenomenon is primarily due to electrophysiological effect of the injectate on the electrical field pattern at the needle tip.

Methods: After ethics approval, five pigs (approx. 20kg), were anesthetized with ketamine, while spontaneous breathing was maintained with 2-3% isoflurane. For each pig, an insulated Tuohy needle was inserted in four sites: left and right brachial plexus, and left and right femoral nerve. For each insertion, the needle was connected to the negative lead of a peripheral nerve stimulator set at a current of 1 mA and frequency of 1 Hz. The needle was advanced until corresponding motor responses were observed. The amplitude was gradually decreased to 0.5mA, with the needle advanced and adjusted toward the nerve being stimulated. The resistance was calculated from the recorded voltage drop between the negative and positive electrodes by a Tektronic Digital Oscilloscope. The effect on the muscle twitch after the injection of 1 mL normal saline (NS), followed by the injection of 1 mL Dextrose 5% in water (D5W) was investigated at the various needle insertion sites.

Result: In all cases, the muscle twitches were abolished immediately after the injection of NS and recovered instantaneously following a subsequent injection of D5W. The figure shows the summary of mean and standard deviations of resistance from baseline following the injection of normal saline followed by D5W at all needle sites.

Discussion: We hypothesize that the injection of local anesthetic or normal saline causes the current previously sufficient to elicit motor responses from the motor nerve (0.5mA) becomes insufficient to reach the threshold. This is because local anesthetic and saline are current conducting solutions, and application of these injectates to the region of the nerve will shunt the electrical current from the needle away from the target nerve. This situation could be reversed through the injection of a non-conducting fluid such as D5W. Thus, the abolition of twitches should depend on the electrical properties of the injected fluid and not on the actual physical displacement of the nerve.

In this study, the electrical resistance between the needle and the ground electrodes decreased immediately after NS injection. The resistance was not only recovered but it was increased following an injection of D5W. This suggests that the injection of conducting NS around the needle shunted some of the electrical current away from the electrode, thus the twitches were abolished. Hence, the findings from our study support above hypothesis.

