

An Animal Model of “Syringe Feel” During Peripheral Nerve Block

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Background: The perception of high resistance during injection of a local anesthetic during regional anesthesia may indicate intraneural injection. Anesthetists’ ability to detect high resistance by “syringe feel” has been questioned in the past. The aim of our study was to investigate the anesthetist’s ability to detect abnormal resistance to injection using an animal model.

Methods: We created a model using nerve, muscle, bone, and tendon tissue dissected from a sheep. Regional anesthesia needles of 21-gauge and 100 mm were placed into each of these tissues under direct vision, and 40 anesthetists were then asked to inject normal saline from a 20-mL syringe. They were unable to see the needle position. Once injected into all 4 tissues, they were asked to state which tissue they thought each was.

Results: Of the 40 anesthetists, 12 (30%) correctly identified the nerve. This was no better than chance (25%) and shows that the tested anesthetists were unable to correctly identify beyond chance what tissues they were injecting into. When those who did not practice regional anesthesia regularly (n = 7) were excluded, similar results were obtained. Ten (30%) of the 33 self-identified experienced regional anesthetists correctly identified the nerve. A score that measured the number of correctly identified tissues (score 1) was used to compare anesthetists on grade and level of experience. This showed that the more experienced anesthetists did better than the less experienced ones.

Conclusion: Under the conditions of this study model, anesthetists were unable to correctly identify intraneural injection by syringe feel during simulated regional anesthesia.

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Serious neurologic damage occurs in 2.4 per 10,000 peripheral nerve blocks.¹ Intraneural injection of local anesthetic during peripheral nerve blockade is thought to contribute to this injury. Objective methods of potentially detecting intraneural injection such as peripheral nerve stimulators, pressure monitors, and ultrasound have been used, but the concept that anesthetists can reliably detect intraneural injection by subjective “syringe feel” is also considered by some to be a viable method for identifying intraneural injection. The term *syringe feel* is used to describe the sensation of the force required to generate a pressure against a certain resistance while injecting local anesthetic. High resistance while injecting is thought to be a possible indication of intraneural injection, which may result in nerve damage.^{2–4} However, the anesthetist’s ability to detect high resistance by this

method has been questioned.⁵ This study was designed to measure anesthetists’ ability to identify different tissues when relying on their perception of the force required to inject into each tissue.

METHODS

No information was kept to identify individual anesthetists, and no live tissue was used; therefore, ethical committee clearance was not required.

We created a model using the nerve, muscle, bone, and tendon of a sheep. Nerve tissue was identified and dissected so that a needle could easily be placed into it under direct vision. Needles were also placed into muscle and tendon and against bone. Regional anesthesia needles (21-gauge, 100 mm; Braun Stimuplex A B. Braun Medical Ltd., Sheffield, United Kingdom) with tubing were used. The tissue and needles were placed in a box with 1 side open to the investigators. The tubings of the needles were passed through 1 side of the box, and 20-mL syringes were attached to each tubing and marked A, B, C, or D. The anesthetists were unable to see which tissue the needles were in, and they were not able to touch the needles; they saw only syringes with tubing. Anesthetists were then invited to inject less than 5 mL of normal saline into each of the 4 tissues and were then asked which syringe (A, B, C, or D) they thought was injecting into which tissue (ie, nerve, tendon, muscle, or against bone). The needles were resited into fresh tissue after each anesthetist’s injection.

Statistical Analysis

One-sample tests for proportions were used to assess whether the correct identification of each of the 4 materials was due to chance. The hypothesized value for the chance proportion of correct guesses for each tissue was 25%; hence, the ability to detect nerve tissue would have to exceed 25% at the 0.05 level of significance to reject the null hypothesis that identification of nerve tissue by anesthetists is random. In addition, a score (score 1) was devised to determine whether level of experience (grade of anesthetists and years of experience) contributed to correct identification of tissues. Score 1 was derived by totaling the correct answers over the 4 materials, yielding a variable (score 1) with values 0, 1, 2, and 3 (as 3 correct responses automatically ensure the correct response to the fourth). We used regression models to assess the independent effects of grades and years of experience in anesthetics on score 1 (linear regressions) and on the binary indicator for correct guess (logistic regression). Power analysis showed that a sample of 40 anesthetists will yield 80% power to detect a difference of 20% (45% vs 25%) in proportion of correct identifications of each 4 materials and will allow the regression models to adjust for the concurrent effects of the 4 covariates. Analysis was performed using STATA v.9 (StataCorp LP, College Station, TX).

RESULTS

Forty anesthetists were investigated. Eleven were consultants, 23 specialist registrars (SpRs), and 6 senior house officers

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(SHOs). The average years of experience was 9 years (range, 1–34 years). When asked whether they conducted regional anesthesia regularly, 7 said they did not.

Table 1A shows each tissue with the proportion of anesthetists who gave a correct answer after injecting. The third column shows the minimum and maximum scores (ie, incorrectly stated [0] or correctly stated [1]) for each tissue. The fourth column displays the mean of correct identifications for each tissue and their 95% confidence intervals (CIs). Table 1B shows the same data excluding those who did not consider themselves regular regional anesthesia practitioners. Two anesthetists refused to identify some of the tissues. Intraneural injections were recognized by only 12 of 40 or 30% (95% CI, 16%–47%) of those tested. The null hypothesis that 25% of each of the tissues would be correctly identified was not rejected. For instance, anesthetists' identification of intraneural injection (30%) did not differ significantly from random choice (25%). Neither did injections into tendons, 10 (25%) of 40. Injections into muscle and against bone were correctly stated by 16 (40%) and 25 (62.5%), respectively, both better than random choice. Similar results were obtained when excluding those who do not consider themselves regular regional anesthesia practitioners as can be seen in Table 1B. Score 1 was similar between those who do and do not practice regional anesthesia regularly.

Table 2 shows the effects of grade (SHO, SpR, and consultant) and years of experience on score 1. SpRs were better at stating the correct tissues than SHOs (coefficient = 1.07; 95% CI, 0.23–1.90; $P = 0.01$), and consultants were better than SHOs (coefficient = 1.39; 95% CI, 0.43–2.35; $P = 0.01$). However, consultants were no better than SpRs in stating the correct tissues. Overall, the effect of grade on score 1 showed that the more experienced you were, the more likely you were to state the tissues correctly ($P = 0.02$). This is further supported by the figures showing the effect of years of experience on Score 1 ($P = 0.03$).

The complete sample of 40 doctors had 80% power to detect a difference of 20% (45% vs 25%) in the proportion of correct identifications for each of the 4 materials. Results were unchanged when examining only those who practiced regional anesthesia regularly, although the significant tests based on this reduced sample would be underpowered and therefore are not presented.

DISCUSSION

Nerve damage after regional anesthesia is a rare event (2.4/10,000),¹ yet any knowledge that may help anesthetists to decrease this complication is beneficial. Through this study, we have examined the ability to detect intraneural injection in a tissue model by means of subjective assessment of the force required to inject or syringe feel.

Controversy exists whether injecting into a nerve causes neurologic damage at all. Bigeleisen⁶ injected into a total of 72

TABLE 1B. Collected Data Excluding Those Who Do Not Practice Regional Anesthesia Regularly

Variable	n	(Min, Max)	Mean (95% CI)
Muscle	33	(0, 1)	0.39 (0.22–0.57)
Tendon	33	(0, 1)	0.24 (0.09–0.40)
Nerve	33	(0, 1)	0.30 (0.14–0.47)
Bone	33	(0, 1)	0.67 (0.50–0.84)
Score 1	33	(0, 3)	1.45 (1.12–1.79)

Abbreviations are explained in the footnote to Table 1A.

nerves during ultrasound-guided axillary plexus block in 26 patients. They were followed up at 6 months. No subject experienced neurologic damage. Russon and Blanco⁷ reported a case of intraneural injection visualized on ultrasound with no neurologic deficit at 6-month follow-up. Iohom et al⁸ injected ropivacaine and saline intraneurally in rat sciatic nerves and evaluated their nerve function using walking track analysis and found no detectable impairment of motor function at any time point. Hertl et al⁹ injected ammonium sulfate, bupivacaine, and saline into the fascicle of the posterior tibial nerves of rats. They noted that there were no abnormalities in serial walking track analysis and that no structural nerve damage was detected. Chan et al¹⁰ also noted that there was no histologic evidence of dysplasia within nerve fascicles of the 24 pig nerves into which they had injected 5% dextrose with ink.

There is, however, contradicting evidence that shows intraneural injection may result in lasting neurologic damage. Hadzic et al³ injected lignocaine into the sciatic nerves of 7 dogs and found that when higher pressures (≥ 25 psi/172 kPa) were required to inject, there was persistent motor deficit up to 7 days after which the dogs were euthanized and sciatic nerves were examined microscopically. This showed significant injury in all nerves injected at high pressure. However, only 4 of 7 intrafascicular injections resulted in high pressure. Selander and Sjostrand² injected local anesthetic into the sciatic nerves of rabbits while investigating the spread of local anesthetic. They found intrafascicular injections to have a higher pressure (39.9–99.7 kPa) than injections within the epineurium (3.3–7.9 kPa). Vuckovic et al¹¹ examined pressure monitoring while injecting intraneurally in rats and found that intraneural injection resulted in a higher pressure (>69.8 kPa/10.1 psi). They did not examine neurologic outcome. Shah et al⁴ reported a case of permanent sciatic injury following a block in which high resistance was noted on injection of the first 1 mL of local anesthetic. The patient did not report any pain during the injection.

Therefore, discrepancy exists within the literature with regard to intraneural injection resulting in nerve damage. An explanation for this may be the lack of clarity as to what constitutes an intraneural injection. There is a difference as to

TABLE 1A. Collected Data With Score 1

Variable	n	(Min, Max)	Mean (95% CI)
Muscle	39	(0, 1)	0.4 (0.25–0.57)
Tendon	39	(0, 1)	0.25 (0.11–0.40)
Nerve	38	(0, 1)	0.3 (0.16–0.47)
Bone	39	(0, 1)	0.63 (0.48–0.80)
Score 1	38	(0, 3)	1.5 (1.15–1.80)

n indicates number of anesthetists; Min, minimum; Max, maximum; Score 1 = number of correct tissues stated (minimum = 0, maximum = 3).

TABLE 2. Simple Linear Regression for Score 1

Score 1	Coefficient	95% CI	P
SpR vs SHO	1.07	–0.23 to 1.90	0.01
Consultant vs SHO	1.39	0.43 to 2.35	0.01
Consultant vs SpR	0.32	–0.39 to 1.04	0.36
Overall grade			0.02
Years of experience	0.04	0.00 to 0.08	0.03

whether the needle is placed intrafascicularly (ie, within the perineurium) or intraepineurally (outside the perineurium but within the epineurium). To know whether this is the case, one requires microscopic examination, and even then, as Hadzic et al³ admit in their study, to place the needle tip intrafascicularly with a microscope is not always successful. This may explain the finding that not all intraneural injections result in nerve damage.

Can anesthetists detect this high pressure that results in nerve damage? Claudio et al⁵ demonstrated that anesthetists often inject at higher pressures than that which causes nerve damage in experimental models. This occurs despite the needle only being submerged in a beaker and not in tissue. They also show that during controlled mechanical injection with different setups of needle, tubing, and syringe, there is a variation in injection pressure. The syringe feel method of assessing the force required to inject is inconsistent and may be further affected by variability in needle design. Our study shows that anesthetists are unable to determine whether the needle tip is placed intraneurally by subjective assessment of the force required to inject. Together with the study of Claudio et al,⁵ there is evidence that syringe feel is a poor indicator of intraneural injection.

There are some limitations to our study. First, the nerve was not live tissue. It was freely dissected and not surrounded by sheath or fascia that may give a higher resistance to injection due to limited space. Second, anesthetists were limited to 5 mL when injecting. However, we felt that this was acceptable as the resistance is highest at the beginning of injection. Third, we did not use a microscope to distinguish between intrafascicular or epineural injection. This may explain the difference in perception between anesthetists. Lastly, the study was not powered to determine significant difference between levels of experience. This, however, was not our goal. Our aim was to assess whether anesthetists performing regional anesthesia as a whole were able to determine by the force required to inject what they were injecting into.

Nerve damage can occur while performing regional anesthesia; however, the means of minimizing the risk of neurologic injury is an ongoing debate. There is evidence that most anesthetists routinely inject with pressures greater than those found to cause nerve damage in animal models. Furthermore, there are various studies contradicting the concept of intraneural injection invariably causing nerve damage. Our study shows that even when uniform syringe, tubing, and regional anesthesia needle setups are used, syringe feel cannot

reliably help anesthetists determine whether their needle tip is placed intraneurally.

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