⬡ Brief Technical Report

Reduced Injection Pressures Using a Compressed Air Injection Technique (CAIT): An In Vitro Study

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Background and Objectives: High injection pressures have been associated with intraneural injection and persistent neurological injury in animals. Our objective was to test whether a reported simple compressed air injection technique (CAIT) would limit the generation of injection pressures to below a suggested 1,034 mm Hg limit in an in vitro model.

Methods: After ethics board approval, 30 consenting anesthesiologists injected saline into a semiclosed system. Injection pressures using 30 mL syringes connected to a 22 gauge needle and containing 20 mL of saline were measured for 60 seconds using: (1) a typical "syringe feel" method, and (2) CAIT, thereby drawing 10 mL of air above the saline and compressing this to 5 mL prior to and during injections. All anesthesiologists performed the syringe feel method before introduction and demonstration of CAIT.

Results: Using CAIT, no anesthesiologist generated pressures above 1,034 mm Hg, while 29 of 30 produced pressures above this limit at some time using the syringe feel method. The mean pressure using CAIT was lower (636 ± 71 vs. 1378 ± 194 mm Hg, $P = .025$), and the syringe feel method resulted in higher peak pressures (1,875 ± 206 vs. 715 ± 104 mm Hg, $P = .000$).

Conclusions: This study demonstrated that CAIT can effectively keep injection pressures under 1,034 mm Hg in this in vitro model. Animal and clinical studies will be needed to determine whether CAIT will allow objective, real-time pressure monitoring. If high pressure injections are proven to contribute to nerve injury in humans, this technique may have the potential to improve the safety of peripheral nerve blocks. *Reg Anesth Pain Med 2008; 33:168-173.*

Key Words: Injection pressure, Intraneural injection, Nerve block techniques, Nerve injury.

Permanent neurological injury is a potentially devastating, albeit rare, complication of peripheral nerve blocks and can occur even in experienced hands.[1,2] Intraneural injection may be a significant cause of neurological injury during peripheral nerve block.[3-5] Severe pain on injection has been associated with intraneural injection and nerve injury during nerve blocks,[1,2] and many clinicians have avoided regional anesthesia in anesthetized or heavily sedated patients who lack responsiveness. Unfortunately, pain is not guaranteed to warn of intraneural injection.[6-10]

Nerve puncture and apparent intraneural injection has been suggested to be quite common but may not invariably cause nerve injury.[7] From animal studies, injection pressure has been suggested to be an important and potentially reliable predictor of nerve injury from intraneural injection.[5,11,12] Specifically, 2 studies by the same group reported that persistent motor deficits were observed in dogs injected intraneurally with pressures ≥20 psi (1,034 mm Hg; conversion factor 1 psi = 51.71 mm Hg)[12] and >25 psi (1,293 mm Hg).[11] Furthermore, the same group has reported that 70% and 50% of a group of anesthesiologists generated injection

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pressures higher than 1,034 mm Hg and 1,293 mm Hg, respectively, at some point during a simulated peripheral nerve block using the typical subjective "syringe feel" method.[13] Although it has not been proven in humans that there is a relationship between high-pressure intraneural injection and nerve injury, if such relationship does exist then it will be vital for anesthesiologists to have the ability to maintain low injection pressures at all time points during injection for peripheral nerve blocks. This is especially important when a simulation study has shown that anesthesiologists can vary widely in their perceptions of forces and rates of injection.[13] These factors as well as the reality that many anesthesiologists hold the needle while an assistant performs the injection, support the development of an objective and real-time pressure monitoring tool. The purpose of this study was to determine if a previously reported[14] specific but simple 50% compressed air injection technique (CAIT) could limit the injection pressures generated, as compared with a commonly used syringe feel method, to below a suggested 1,034 mm Hg limit in an in vitro model. Our hypothesis was that most anesthesiologists would not generate an injection pressure above a "high" injection pressure of 1,034 mm Hg at some time point during their injection using CAIT. Secondary objectives were to show that CAIT can result in lower overall mean and peak pressures than a typical syringe feel method of injection.

Methods

After obtaining approval from the Research Ethics Board (University of Alberta and Royal Alexandra Hospitals, Edmonton, Alberta, Canada), 30 staff anesthesiologists (15 from each hospital) consented to participate in this study. The study consisted of 2 parts: (1) a control trial using the typical syringe feel method, and (2) an experimental trial using CAIT. During the consent process, the anesthesiologists consented to first have their typical injection technique assessed for pressure generation, without informing them about the study's pressure limit; they also consented to participate in a trial of a "new" injection technique which they would perform after they received verbal instructions and a demonstration by one of the investigators. They all performed their typical injection method prior to any information specifically related to CAIT.

The experiment consisted of injecting saline into a semi-closed system. The system was created by inserting a commonly used insulated needle (50 mm, 22 gauge; B. Braun Medical Inc., Bethlehem, PA) into a heplock/injection port (Interlink Injection Site, Baxter Corp. Mississauga, ON, Canada), connected to an in-line pressure sensor (Asena® CC-MKIII, ALARIS™ Medical UK Ltd., Basingstoke, UK) with intravenous tubing partially clamped at its end. The system's resistance was tested in our previous experiment,[14] where injections using a pump at a rate of 600 mL per hour could be performed at pressures in the range of 1,000 to 1,300 mm Hg.

Anesthesiologists' injection pressures using 2 separate 30 mL syringes (BD, Franklin Lakes, NJ), each containing 20 mL of saline, were measured for 60 seconds in 2 parts: (1) a control trial using the same speed and force they would normally use (i.e., assumed to be the syringe feel method), and (2) an experimental trial using CAIT, thereby drawing 10 mL of air into the syringe above the 20 mL saline and compressing this air to 5 mL prior to and during the injection (Fig 1). The anesthesiologists were not able to see the screen of the pressure sensor. For the syringe feel trial, the subjects were instructed to perform the injection in their usual manner; for both trials, they were not instructed to stop injecting at any specific time, nor were they told to continue injecting regardless of perceived high pressure. For the experimental trial, the anesthesiologists were given an individual instructional lesson with verbal instructions, a handout containing Figure 1, and a short demonstration by one of the investigators. The screen of the

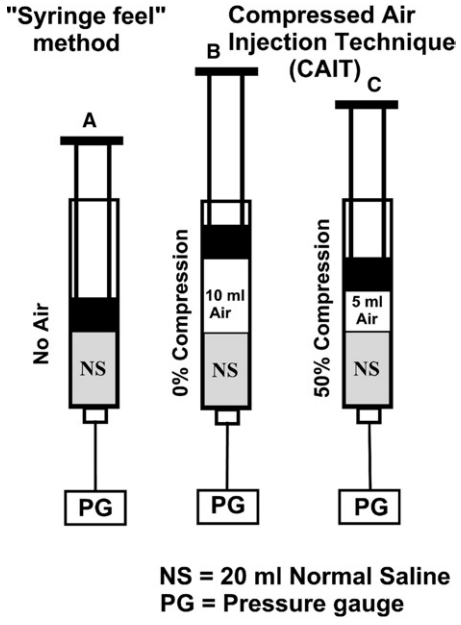

Fig 1. "Syringe feel" and CAIT techniques. (A) Syringe feel method. CAIT technique; (B) air is drawn into the syringe above the normal saline, and (C) compressed to 50% prior to and during the injection. The net pressure is maintained at approximately 760 mm Hg. CAIT, compressed air injection technique.