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Achieving the optimal epinephrine effect in wide awake hand surgery using local anesthesia without a tourniquet

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Abstract
Background In our experience, for all surgeries in the hand, the optimal epinephrine effect from local anesthesia—producing maximal vasoconstriction and visualization—is achieved by waiting significantly longer than the traditionally quoted 7 min from the time of injection.
Methods In this prospective comparative study, healthy patients undergoing unilateral carpal tunnel surgery waited either 7 min or roughly 30 min, between the time of injection of 1 % lidocaine with 1:100,000 epinephrine and the time of incision. A standardized incision was made through dermis and into the subcutaneous tissue followed by exactly 60 s of measuring the quantity of blood loss using sterile micropipettes.
Results There was a statistically significant reduction in the mean quantity of bleeding in the group that waited roughly 30 min after injection and before incision compared to the group that waited only 7 min (95 % confidence intervals of 0.06+−0.03 ml/cm of incision, compared to 0.17+−0.08 ml/cm, respectively) (P=0.03).
Conclusions Waiting roughly 30 min after injection of local anesthesia with epinephrine as oppose to the traditionally taught 7 min, achieves an optimal epinephrine effect and vasoconstriction. In the hand, this will result in roughly a threefold reduction in bleeding—making wide awake local anesthesia without tourniquet (WALANT) possible. This knowledge has allowed our team to expand the hand procedures that we can offer using WALANT. The benefits of WALANT hand surgery include reduced cost and waste, improved patient safety, and the ability to perform active intraoperative movement examinations.

Keywords Wide awake · Hand surgery · Local anesthesia · Epinephrine · Adrenaline · Quantify · Vasoconstriction · Comparative study · Micropipette · Timing · No tourniquet

Meeting Presentations At the time of paper submission, this study has not been presented at any meetings.

Author's Roles/Participation in the Authorship Dr. Daniel McKee was the primary investigator and contributed substantially to the conception, analysis, interpretation, drafting, and revision of the manuscript submission.
Dr Donald Lalonde conceived the idea for the study and contributed substantially to the conception, analysis, interpretation, drafting, and revision of the manuscript submission.
Dr. Achilleas Thoma was the local principal investigator and contributed substantially to the conception, analysis, interpretation, drafting, and revision of the manuscript submission.
Lisa Dickson conceived the idea for the study and contributed substantially to the conception, analysis, interpretation, drafting, and revision of the manuscript submission.

List of products, drugs, devices (*also listed in Methods section*) Lidocaine 1 % with 1:100,000 epinephrine (0.01 mg/ml) (AstraZeneca Canada Inc).

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Introduction

Bleeding can be minimized in hand surgery by waiting for the optimal epinephrine effect after local anaesthetic injection. This principle has allowed our team to perform the majority of hand procedures with excellent visualization using wide awake local anesthesia and no tourniquet (WALANT) [1, 5]. Surgeons who do not use WALANT rely instead on an arm tourniquet to prevent bleeding; however, awake patients can only tolerate an arm tourniquet for roughly 20 min—

obligating the surgeon who relies on the tourniquet to perform lengthier hand procedures in the main operating room. WALANT has several advantages over performing hand surgery in the main operating room: reduced cost and waste, improved patient safety, and the ability to perform active intraoperative movement examinations [2, 7, 10, 11]. In WALANT, if the local anesthetic injection is not planned early enough prior to the incision, the optimal epinephrine vasoconstriction effect will not be obtained. In our experience, the optimal epinephrine effect is achieved by waiting significantly longer than the traditionally quoted 7 min for maximal vasoconstriction, from the time of injection of lidocaine and epinephrine to the time of incision [3, 4, 9]. The timing needed to achieve the optimal epinephrine vasoconstriction effect was evaluated in this study by comparing the quantity of bleeding in hand surgery after waiting different time periods from injection of local anesthetic with epinephrine to incision.

Materials and Methods

In this prospective comparative study, healthy patients undergoing unilateral carpal tunnel surgery waited either 7 min or roughly 30 min between the time of injection and the time of incision. Exclusion criteria included repeat carpal tunnel release, patients on an anticoagulation medication, and patients with a bleeding disorder. For local anesthesia injection, we used 10 cm [11] of 1 % lidocaine with 1:100,000 concentration of epinephrine introduced in a subcutaneous plane along an interthenar longitudinal incision over the carpal tunnel, with the injection being provided by the same injector for all patients (AstraZeneca Canada, Inc., Ontario, Canada). A carpal tunnel incision (between 2.5 and 3.0 cm) was performed through dermis and into the subcutaneous tissue to a standardized predetermined depth of roughly 1 cm, followed by exactly 60 s of measuring blood loss using a sterilized disposable micropipette and a capped syringe with graduated lines every 0.01 ml, (Fig. 1) (Lab Depot, Inc., Georgia, USA) (Becton, Dickinson and Company, New Jersey, USA). We accounted for differences in incision lengths by calculating the blood loss in millimeters per centimeter of skin incision. Fifteen patients were recruited consecutively during the time period assigned to minor procedure research. The study sample size was based on a sample size calculation performed on a related study we published that indirectly measured the same endpoint [12]. For seven patients, we waited exactly 7 min before cutting, and for the other eight patients, we waited roughly 30 min. We did not plan to wait exactly 30 min for the second group, as the time delay depended on what other multitasking procedures, clinical consultations, or paperwork was being performed by the primary surgeon—as in real clinical practice. The patients were not formally randomized but were allocated prior to arriving to the hospital based on surgeon scheduling factors.

Fig. 1 Photograph of an intraoperative measurement quantifying micro quantities of blood loss from a carpal tunnel incision after previous injection of local anesthesia and epinephrine

Results

The 7 min group and the 33 min group had a demographic patient mean of 53 and 56 years old, respectively, and a male to female ratio of 3:4 and 5:3, respectively. The study found a statistically significant, near threefold reduction in the mean quantity of bleeding in the group that waited a mean of 33 min (range; 23–45 min) after injection and before incision compared to the group that waited exactly 7 min (95 % confidence intervals of 0.06+−0.03 ml/cm of incision, compared to 0.17+−0.08 ml/cm, respectively) (P=0.03).

Discussion

The results of this study confirm our clinical experience that waiting 26–30 min as oppose to the traditionally taught 7 min, results in less intraoperative bleeding in the hand. No studies to date have measured micro quantities of intraoperative bleeding to assess the effects of local anesthetic and epinephrine on vasoconstriction in humans. Studies have previously relied on indirect measures such as laser Doppler flowmetry and NIR spectroscopy [12, 13].

The time delay for optimal vasoconstriction and hemostasis using local anesthesia with epinephrine can be explained by two phenomena. Firstly, epinephrine's vasoconstriction effect has to work against the vasodilation effect of lidocaine and histamine release from the trauma of the needle and the injected fluid. Dilute epinephrine without lidocaine would have a quicker onset to time to maximal vasoconstriction. Secondly, the new vasoconstriction equilibrium within the

surgical zone is not achieved until the gradual diffusion of the injected local anesthesia solution travels beyond the subcutaneous tissue injection site, and into the deep crevices of the carpal tunnel and the deep spaces of the hand which supply feeding blood vessels to the surgery zone and overlying skin. After the gradual diffusion and activation of both lidocaine and epinephrine, a new vasomotor equilibrium is reached involving the surrounding network of veins, venules, arteries, arterioles, and capillaries. A qualitative finding in this study that may support this diffusion hypothesis is that we observed frequent patient complaints of intraoperative nerve irritation shocks in the group that waited only 7 min, whereas there were no nerve irritation shocks in the group that waited roughly 30 min. In this study, we did not perform regional median nerve blocks, and instead relied on the local anesthetic injected into the subcutaneous tissue to diffuse down to the median nerve. This is in contrast to the practice of some surgeons who inject additional volumes of local anesthesia directed proximally to the carpal tunnel—thus, performing a median nerve block—leading to quicker anesthesia of the nerve [8]. Diffusion time of local anesthesia likely contributes to the time delay observed in (1) the optimal epinephrine effect on vasoconstriction in the zone of surgery and (2) adequate anesthesia of the median nerve when only a subcutaneous anesthetic injection is performed [6].

Waiting for the optimal epinephrine effect is one of the key components of WALANT, and it has allowed our team to expand the list of hand procedures that we can offer under local anesthesia alone without a tourniquet, including tendon repair, tendon grafting, tendon transfer, tenolysis, hand fracture open reduction and fixation, joint fusion, arthroplasty, trapeziectomy, dupuytren's contracture partial fasciectomy, trigger finger release, and carpal tunnel release [5]. The drawback of waiting for the maximal epinephrine effect is that it requires the surgeon to multitask either by tending to non-operative tasks or performing surgery on another patient while the first one waits. We have found that WALANT is quite time efficient considering the time saved by avoiding the long turnover times associated with the main operating room and general anesthesia. In regard to the study methodology, a paired control would improve the effect size by compensating for coagulation differences among patients. Other limitations of this study were that we did not perform formal randomization and blinding. This study measured a near threefold reduction in the quantity of bleeding from skin and superficial subcutaneous tissue incisions only; however, in our experience, the percentage reduction in bleeding can be extrapolated for the entire surgical procedure involving incisions to deeper tissues. This study methodology—measuring micro quantities of bleeding—opens up the possibility to perform similar protocols at various other body locations, at different anesthetic concentrations, and at various time delays.

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Conflict of Interest Daniel E. Mckee, Donald H. Lalonde, Achilleas Thoma and Lisa Dickson declare that they have no conflict of interest.

Statement of Human and Animal Rights All procedures were performed in accordance with McMaster University's ethical and protocol standards, and guided by the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent Informed consent was obtained for all patients.

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