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Onset and duration of anesthesia for local anesthetic combinations commonly used in forefoot surgery; surprise results with sequential blocks

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HIGHLIGHTS

- Sequential local anesthetic blocks may not be warranted.
- Mixing local anesthetics decreases the expected duration.
- Bupivacaine is a useful local anesthetic agent in digital surgery.

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ABSTRACT

Local anesthetic nerve blocks are frequently used for postoperative analgesia and to the best of our knowledge no studies have evaluated the effects of injecting bupivacaine into an area previously injected with lidocaine. Sensation was tested in three groups of subjects receiving local anesthetic digital blocks. Group A received bupivacaine 0.25% plain. Group B received a 1:1 mixture of lidocaine 1% plain and bupivacaine 0.25%. Group C received an initial block of lidocaine 1% plain sequentially followed by bupivacaine 0.25% 1 h later. Bupivacaine exhibited a delayed onset and the longest duration when compared to the other two groups. The group receiving the 1:1 mixture showed a rapid onset that resembled that of lidocaine and a shortened duration that did not resemble bupivacaine. The group receiving the sequential injections showed that even after a 1 h interval following the lidocaine infiltration, there was a deleterious effect on duration of action of the bupivacaine. Using bupivacaine as a post-surgical block in the presence of residual lidocaine from a preoperative block is not warranted as once again, the extended duration of bupivacaine is mitigated. Bupivacaine alone as an initial operative block affords clinically acceptable onset of anesthesia while also providing extended duration of action.

1. Introduction

Traditionally, preoperative and postoperative nerve blocks are used during forefoot surgery. Two common local anesthetics used for these nerve blocks are lidocaine and bupivacaine. They can be used individually or combined for a mixed injection. These are frequently followed by a postoperative block with bupivacaine which is an anesthetic with a relatively long duration. The intended rationale with respect to mixing solutions is to obtain the rapid onset of the lidocaine and the prolonged duration of the bupivacaine. However, past literature suggests that a nerve block consisting of

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a mixture of lidocaine and bupivacaine decreases the anesthetic duration of the bupivacaine plain [1]. To the best of our knowledge, sequential nerve blocks given in the same area have not been investigated in the literature with respect to effects on onset or duration.

The purpose of this research was to compare local anesthetics alone and in combination in order to determine the most effective anesthesia when used in common forefoot surgery. The primary objective of the study was to evaluate whether using lidocaine as an initial block followed 60 min later with bupivacaine has any effect on anesthetic duration compared to bupivacaine alone and a 1:1 mixture of lidocaine and bupivacaine. It was hypothesized that the anesthetic duration of the group receiving bupivacaine after an initial lidocaine injection would be longer than the group receiving bupivacaine alone or the group receiving the 1:1 mixture. The secondary objective of the study was to evaluate the onset of anesthesia for the three above-mentioned groups of local anesthetics. Here it was hypothesized that the onset of anesthesia for the group receiving lidocaine as well as the group receiving the mixture of lidocaine and bupivacaine would be essentially the same whereas the group receiving bupivacaine alone would be longer.

2. Materials and methods

Subjects for this study were recruited from the student body of the Kent State University College of Podiatric Medicine (KSUCPM). This study was approved by the KSUCPM Institutional Review Board, and subjects were required to sign consent forms before participating. The anesthetics that were used in the study were lidocaine HCl (Xylocaine®, AstraZeneca LP, Wilmington, DE) and bupivacaine HCl (Marcaine®, Hospira, Inc., Lake Forest, IL). A sample size of 45 subjects was required for this study, as determined by a power analysis using G*Power 3.1 statistical power analysis software [2,3]. In this analysis alpha was set to 0.05 and the desired power was 0.95. Subjects were randomly assigned to one of three groups: Group A received a nerve block of the left second digit with 2 ml of bupivacaine 0.25% plain ($n = 15$); Group B received a nerve block of the left second digit with 2 ml of a 1:1 mixture of lidocaine 1% plain and bupivacaine 0.25% plain ($n = 15$); and Group C received two separate nerve blocks of the left second digit ($n = 15$). The first nerve block for Group C consisted of 2 ml lidocaine 1% plain followed 60 min later by a second nerve block of 2 ml bupivacaine 0.25% plain administered in the same location. The 60 min point was used as the time to administer the second injection because common forefoot surgical procedures, such as hammertoe correction, are typically completed within this time frame. The primary endpoint to be measured was duration time of anesthesia, while the secondary endpoint was time to onset of anesthesia. Subjects in Groups A and B were blinded as to whether they received bupivacaine alone or the lidocaine/bupivacaine mixture.

Prior to the administration of the nerve blocks, protective sensation was assessed using the Semmes–Weinstein 5.07 monofilament to ensure intact sensation in all participants. Before initiating the study, investigators were trained on proper technique to minimize inter-operator measurement variability. The Semmes–Weinstein testing was performed by having the subjects close their eyes while investigators touched the tip of the filament to the distal aspect of the second digit, just inferior to the nail plate, applying just enough pressure for the filament to bend. Prior to applying the monofilament, the subjects were instructed to respond with a "yes" if they detected the sensation.

After determining that sensation was intact, the anesthetic was injected into the second digit of the left foot via a 25 gauge, 1.5-inch needle. The syringes were loaded with the anesthetic within 24 h of the injection. Injections were performed via the "two point" method for a lesser digit, which consisted of an initial injection of 1 cc into the proximal medial aspect of the digit, removal of the needle, and then a second injection of 1 cc into the proximal lateral aspect of the digit. One investigator (MMB) performed all of the injections.

The methods used for determining onset and duration were adapted from those established by Ribotsky et al. [1]. After the injection, the time to onset of anesthesia was determined by applying the Semmes–Weinstein filament as described above every 15 s for the first 2 min, and then every minute until onset of anesthesia was achieved. The onset of anesthesia was defined as the time at which the subject first failed to detect sensation after the application of the monofilament.

After onset was established, the duration of anesthesia was determined also as per Ribotsky et al. [1]. For subjects in Groups A and B, protective sensation was assessed at the 15, 25, 40, and 60 min marks following onset and then every 60 min until sensation returned. For Group C, protective sensation was assessed at the same time intervals to determine if there was continued anesthesia of the digit prior to the second injection. The second injection was administered at the 60 min mark and protective sensation was assessed every 60 min until sensation returned. If the subject regained protective sensation before the administration of the second injection, the time at which sensation returned was recorded and a second time to onset of anesthesia was assessed every 15 s for the first 2 min, and then every minute until onset of anesthesia was again achieved. Sensation was then assessed every 60 min until sensation returned. The duration of anesthesia for Group C was measured from the time of the 2nd injection.

Differences in time to onset of anesthesia and duration of anesthesia between the three groups were statistically analyzed using one-way ANOVA with significance defined as $p < 0.05$. Pairwise multiple comparisons were conducted using the Holm–Sidak method. SigmaStat® 3.5 software was used for these analyses.

3. Results

A total of 48 patients were initially enrolled into the study. After receiving the initial injection of anesthetic, 3 patients did not lose protective sensation and were removed from the study. Thus, a total of 45 patients, 15 in each experimental group, completed the study.

The results for time to onset of anesthesia are shown in Fig. 1. For subjects in Group A, the mean time to onset of anesthesia was 8.70 ± 4.29 min (range: 1.5–17 min). For Group B, the mean time

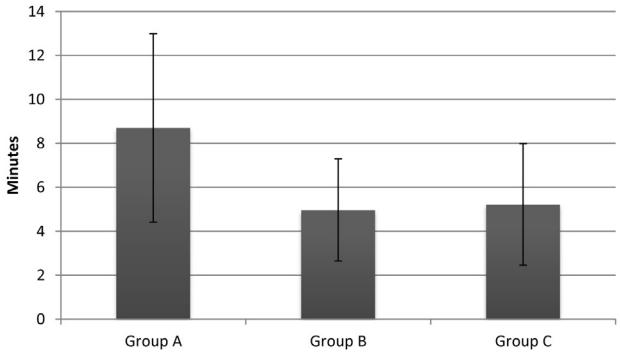

Fig. 1. Mean time to onset of anesthesia. Group A – bupivacaine 0.25% plain; Group B – 1:1 mixture of lidocaine 1% plain and bupivacaine 0.25% plain; Group C – lidocaine 1% plain followed by bupivacaine 0.25% plain.