Volume of 4% sodium bicarbonate required to remove pain in tumescent anaesthesia for endovenous laser ablation of saphenous veins: a randomized, double-blind, controlled trial

Oksana Vasilyevna Bukina*

INTRODUCTION

Endovenous laser ablation (EVLA) is the most popular surgical treatment for varicose veins in many countries. This procedure is often performed under local anaesthesia. However, subcutaneous injection of local tumescent anaesthetics may cause discomfort because of the acidity of the solution. Adding sodium bicarbonate reduces the pain associated with local infiltration anaesthesia [1-14].

OBJECTIVE

Our aim was to compare the level of pain associated with subcutaneous infiltration of the lidocaine solution with epinephrine at different pH levels and to find the optimal volume of 4% sodium bicarbonate to use in the tumescent solution.

METHODS

This study was designed as a prospective, double-blind, randomized, controlled trial in an outpatient department specializing in venous disease (more than 400 surgical procedures per year performed under local tumescent anaesthesia alone) in a multidisciplinary clinic. The study protocol was approved by the regional ethics committee (No.376-B, Ethics Committee of the Medical Faculty of Derzhavin Tambov State University).

Results: In total, 74 patients undergoing EVLA were randomized to receive either buffered solution at pH 7.1 (group A) or buffered solution at pH 6.63 (group B). Median pain scores (interquartile range) were significantly lower in patient group A than in group B (0.65 (0.2-1.38) versus 1.65 (0.87-3.5), p<0.01).

Conclusions: These results show that tumescent anaesthesia for EVLA of saphenous veins is less painful if the local anesthetic is buffered prior to its infiltration. Nonetheless, the buffering may be inadequate. We advise adding 143 mL of 4% sodium bicarbonate to 1000 mL 0.08% lidocaine so that the pH of the solution is increased to 7.1 and the intraprocedural pain is reduced significantly.

Key Words: Tumescent anaesthesia, Infiltration pain, Endovenous laser ablation, Saphenous veins, Sodium bicarbonate.
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gauge). It was necessary to reduce the pain from needleling using larger bore needles (21 gauge). Tumescent anaesthesia was performed without a pump for both groups.

In all patients, EVLA was supplemented by Varady phlebectomy. However, in view of the recommendation and blindness we believe that phlebectomy influences pain in both groups equally, and we did not account for the phlebectomy in comparing groups.

The pain during injection of local anaesthetics was estimated with a visual analogue scale (VAS) that ranges from 0 (indicating no pain) to 10 (indicating the most extreme pain possible). The VAS was tested on each patient by a person independent of the physician after the operation. The physician paid attention to reports by each patient of the pain they felt at the stage of anaesthesia.

STATISTICAL ANALYSIS

Analyses were performed using the IBM SPSS Statistics v 20.0 software package. Qualitative characteristics of the samples were tested with the \( \chi^2 \) test. For group comparisons of the quantitative values, the Mann-Whitney U test or Student’s independent samples t-test was used. A \( p \)-value of <0.05 was considered to indicate statistical significance.

RESULTS

According to the recommendations of Jeffrey A. Klein, an addition of 12.5 mL 8.4% sodium bicarbonate to 1000 mL of the 0.05% lidocaine solution results in a concentration of sodium bicarbonate of \( \approx 0.1\% \). We calculated it by the formula \( p_2 = p_1 / (b/A + 1) \), where \( p_1 \)-concentration of sodium bicarbonate before dilution, \( p_2 \)-concentration of sodium bicarbonate after dilution, \( b \)-volume 0.9% NaCl, and \( A \)-volume of sodium bicarbonate before dilution. However, we used 4% sodium bicarbonate, which is why we added 25.6 mL 4% sodium bicarbonate to 1000 mL 0.05% lidocaine solution. We calculated it by the formula \( A = b / (p_2 / p_1 - 1) \), where \( p_2 \)-concentration of sodium bicarbonate before dilution, \( p_1 \)-concentration of sodium bicarbonate after dilution, \( b \)-volume 0.9% NaCl, and \( A \)-volume of sodium bicarbonate before dilution.

The concentration of sodium bicarbonate became 0.1%, but the pH reached only 6.9. In a separate solution, we used 0.08% lidocaine. When we added 26 mL 4% sodium bicarbonate to 1000 mL 0.08% lidocaine solution, the pH became 6.63. By means of titration, it was established that a pH of 7.1 was achieved by adding 143 mL 4% sodium bicarbonate to 1000 mL 0.08% lidocaine solution. Because of these results, we performed the trial by comparing two separate tumescent solutions that differed in their buffering. The pH of buffered solution A was 7.1, and the pH of buffered solution B was 6.63 (Table 1).

<table>
<thead>
<tr>
<th>Solution A</th>
<th>Solution B</th>
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<tbody>
<tr>
<td>Cold NaCl 0.9% (4°C)</td>
<td>1000 mL</td>
</tr>
<tr>
<td>10% lidocaine</td>
<td>8 mL</td>
</tr>
<tr>
<td>0.1% epinephrine</td>
<td>0.4 mL (1:2,000,000)</td>
</tr>
<tr>
<td>4% sodium bicarbonate</td>
<td>143 mL</td>
</tr>
<tr>
<td>pH</td>
<td>7.1</td>
</tr>
</tbody>
</table>

The patients were randomized into two groups: group A consisted of 34 patients who received the tumescent solutions with a pH of 7.1, and group B consisted of 40 patients who received the tumescent solutions with a pH of 6.63.

No significant differences were noted in terms of gender, mean age, CEAP classification, ratio of SSV/GSV and mean volume of solution injected during tumescent anaesthesia between the two groups (Table 2).

<table>
<thead>
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<th>Table 2: Baseline patient characteristics.</th>
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<tr>
<td>Group A (n=34)</td>
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<tr>
<td>Mean age</td>
</tr>
<tr>
<td>Gender (men/women)</td>
</tr>
<tr>
<td>CEAP Clinical grade</td>
</tr>
<tr>
<td>C2</td>
</tr>
<tr>
<td>C3</td>
</tr>
<tr>
<td>C4</td>
</tr>
<tr>
<td>C5</td>
</tr>
<tr>
<td>Mean volume of solution, mL</td>
</tr>
<tr>
<td>Ratio of SSV/GSV</td>
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</tbody>
</table>

*Student’s independent samples t-test; ^\chi^2 test.

The median (interquartile range) pain score (VAS) in group A was 0.65 (0.2-1.38), whereas the pain score in group B was 1.65 (0.87-3.5) (Figure 1). According to the Mann-Whitney U test, the difference between the mean values for pain scores was statistically significant (\( p < 0.01 \)). Five of the 34 patients (14.7%) of group A felt no pain (pain score of 0) while in group B, there were no scores of 0 (\( p < 0.02 \)). We reasoned that severe pain was represented by a score of 5 or greater. In group A, there was only one score of 5 or greater (2.9%), and in group B there were six values of 5 or greater (15%); but the difference between the groups did not reach statistical significance, as measured by a \( \chi^2 \) test (\( p > 0.05 \)) (Table 3). The maximum pain score was lower in group A (5.9) than in group B (8.7). In group A, most scores were between 0 and 1. In group B, there were fewer scores between 0 and 1 than in group A, and the distribution of points was uniform between 1.1 and 9. The pain scores from one patient (5.9) from group A and four patients (7.1-8.7) from group B differed greatly from those of the other participants. We believe that the severe pain of these patients was due to their extremely low pain threshold. No adverse events were reported.

<table>
<thead>
<tr>
<th>Table 3: The pain score on the Visual Analog Scale (VAS) in group A and group B.</th>
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<tbody>
<tr>
<td>Median pain score (interquartile range)</td>
</tr>
<tr>
<td>No pain score</td>
</tr>
<tr>
<td>Pain score 5 or greater</td>
</tr>
</tbody>
</table>

*Mann-Whitney U test.

Complications and side-effect (systemic toxicity, CNS reactions, cardiovascular reactions, local tissue toxicity, and hypersensitivity reactions including anaphylaxis) was not detected in each group.
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**DISCUSSION**

We believe that the level of pain experienced by patients during tumescent anaesthesia depends on the amount of sodium bicarbonate that is part of the solution. With the use of small doses of sodium bicarbonate the pH of the solution does not reach alkaline values, and thus patients feel uncomfortable [1,4]. This fact can explain the results of some previous studies in which the difference in pain between groups of patients treated with buffered and unbuffered solution was insignificant. The pH of the buffered solution in this study was 7.05 [1,4]. In more recent studies, researchers have used Klein's solution in which the volume of the buffer was 2 times more than in the earlier studies. In later studies, the difference in the pain between buffered and unbuffered solutions was significant [7,8,13].

In most studies the median score for pain in groups in which patients received anaesthesia with a buffered solution were in the range of 1.75 to 2.11 [11]. This is slightly above the median score for pain in patients in group A in our study. Perhaps this is due to the fact that immediately prior to infiltration by anaesthetic under the skin we anesthetized the skin with a small diameter needle.

Different countries produce sodium bicarbonate in various concentrations: 4%, 5%, 7%, 8.4%, and 10%. According to the recommendation of J. Klein, a 0.1% solution is obtained by dilution of 12.5 mL 8.4% sodium bicarbonate in 1000 mL tumescent solution [12].

If 4% sodium bicarbonate is used for buffering and the concentrations of the solutions are recalculated to make a 0.1% solution, the desired alkaline pH values will not be achieved. This is because the buffer capacity depends on the concentration of the solution, but is not directly proportional to it. But Klein's solution contains 0.05% lidocaine. If a concentration of more than 0.05%, for example 0.08%, is applied to the same lidocaine, the pH will be even lower.

Therefore, for solutions containing different amounts of lidocaine it is necessary to determine the exact amount of sodium bicarbonate required to achieve slightly alkaline pH values close to physiological levels. We found an optimal volume of 4% sodium bicarbonate, which was able to bring the pH of 0.08% lidocaine and epinephrine to 7.1 and greatly ease the pain during anaesthesia. However, we calculated the amount of sodium bicarbonate only for the amount of lidocaine and epinephrine, which are used in our practice. If a different concentration of lidocaine or sodium bicarbonate is used, it is necessary to titrate the amount of sodium bicarbonate to a pH of 7.1.

Although the pH of the solution in our study was slightly alkaline and did not reach physiological values (7.35-7.45), the pain score did not differ significantly from data obtained in a recent study in which a buffered solution with pH 7.4 was used for tumescent anaesthesia in the EVLA [13]. The pH of commercial lidocaine, epinephrine and 0.9% NaCl can differ considerably and be more alkaline than that used in our study.

In clinical practice, we do not determine the pH of all the components of the tumescent solution. We can easily be wrong and prepare a solution with a pH more than 7.4. Too much alkalization can lead to precipitation of the anaesthetic, rendering it unsafe for use (may lead to tissue necrosis) [15]. Therefore, there is no need to bring the pH of the tumescent solution to physiological values; it is sufficient to use a solution with a pH in the range of 7.1 to 7.35.

Among our patients there were some with hyperalgesia. They are unable to comfortably receive any form of local anaesthesia. This is a small group which requires the use of sedative drugs during an operation.

**Limitations to the study**

1. We compared the pain associated with local infiltration anaesthesia by two buffered solutions with different pH but we did not compare with the pain score of unbuffered solution.

2. The pH of commercial lidocaine, epinephrine and 0.9% NaCl can differ considerably and be more alkaline or acid than that used in the present study.

3. We calculated the amount of sodium bicarbonate only for 0.08% lidocaine.

4. Randomization using the method of envelopes is not the best method of randomization.

5. Pain assessment was performed after surgery but not immediately after anaesthesia.

6. Phlebectomy could influence the assessment of pain. But randomization equalizes the influence of phlebectomy in the two groups.

**CONCLUSIONS**

The tumescent anaesthesia for EVLA of saphenous veins is less painful if the local anaesthetic is buffered prior to its infiltration. Nonetheless, the buffering may be inadequate. We believe that no need to bring the pH of the tumescent solution to physiological values; it is sufficient to use a solution with a pH in the range of 7.1 to 7.35. We advise adding 143 mL of 4% sodium bicarbonate to 1000 mL 0.08% lidocaine so that the pH of the solution is increased to 7.1 and the intraprocedural pain is reduced significantly. If a different concentration of lidocaine or sodium bicarbonate is used, it is necessary to titrate the amount of sodium bicarbonate to a pH of 7.1.

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None

**REFERENCES**


