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*

Background: Sodium bicarbonate in tumescent anaesthesia for endovenous laser ablation (EVLA) of saphenous varicose veins is underused. Objective: To find the volume of 4% sodium bicarbonate required to significantly reduce intra-procedural pain. Methods: Tumescent solution ingredients were determined by recalculation based on the Klein solution and was titrated to a slightly alkaline pH by buffering with 4% sodium bicarbonate. The outcome variable was the level of intra-procedural pain measured with a visual analogue scale. 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 anaesthetic 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 intra-procedural pain is reduced significantly.

Key Words: Tumescent anaesthesia, Infiltration pain, Endovenous laser ablation, Saphenous veins, Sodium bicarbonate.

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]. Most dermatologists and surgeons use lidocaine with epinephrine to prolong the half-life of the anaesthetic, reduce toxicity, and provide haemostasis. Lidocaine with epinephrine is buffered with sodium bicarbonate to a slightly alkaline pH of 7.0 to 7.4 to reduce the pain on infiltration of the local anaesthetic solution. This mixture, including 8.4% sodium bicarbonate, was suggested by Klein [12]. In this study, we used a different concentration of sodium bicarbonate, 4%, because in our country we do not have 8.4% sodium bicarbonate.

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).

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gauge). It was necessary to reduce the pain from needling 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 randomization and blinding 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 χ² 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 ≈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 $p_1$-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.

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 1: Mixture and pH of the tumescent solution prepared by the nurse before the procedure.

<table>
<thead>
<tr>
<th>Solution A</th>
<th>Solution B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold NaCl 0.9% (4°C)</td>
<td>1000 mL</td>
</tr>
<tr>
<td>10% lidocaine</td>
<td>1000 mL</td>
</tr>
<tr>
<td>0.1% epinephrine</td>
<td>8 mL</td>
</tr>
<tr>
<td>0.4 mL (1:2,000,000)</td>
<td>8 mL</td>
</tr>
<tr>
<td>4% sodium bicarbonate</td>
<td>0.4 mL (1:2,000,000)</td>
</tr>
<tr>
<td>pH</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>6.63</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>
<tr>
<th>Table 2: Baseline patient characteristics.</th>
<th>Group A (n=34)</th>
<th>Group B (n=40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>44.8 ± 12.2</td>
<td>45.1 ± 9.5</td>
<td>p&gt;0.5</td>
</tr>
<tr>
<td>Gender (men/women)</td>
<td>25/9</td>
<td>33/7</td>
<td>p&gt;0.5</td>
</tr>
<tr>
<td>CEAP Clinical grade</td>
<td>73.5%/25.5%</td>
<td>82.5%/17.5%</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>29</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>4</td>
<td>6</td>
<td>p&gt;0.5</td>
</tr>
<tr>
<td>C4</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean volume of solution, mL</td>
<td>44.8 ± 153.7</td>
<td>433.5 ± 172.6</td>
<td>p&gt;0.2</td>
</tr>
<tr>
<td>Ratio of SSV/GSV</td>
<td>2.90%</td>
<td>12.50%</td>
<td></td>
</tr>
</tbody>
</table>

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 χ² 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 3: The pain score on the Visual Analog Scale (VAS) in group A and group B.

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=34)</th>
<th>Group B (n=40)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median pain score (range)</td>
<td>0.65 (0.2-1.38)</td>
<td>1.65 (0.87-3.5)</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>No pain score</td>
<td>5/34</td>
<td>0/40</td>
<td>p&gt;0.02</td>
</tr>
<tr>
<td>Pain score 5 or greater</td>
<td>1/34</td>
<td>6/40</td>
<td>p&gt;0.05</td>
</tr>
</tbody>
</table>

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

*Student’s independent samples t-test; χ² test.
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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 alcalization 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 hyperalgiesia. 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 anesthesia 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 intraoperative 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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CONFLICT OF INTEREST/FUNDING
None

REFERENCES