

Improvement in pain and patient comfort during injection of local anaesthesia with the use of sodium bicarbonate

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Background

The beneficial effect of adding 8.4% sodium bicarbonate (NaHCO_3) to local anaesthesia, making it less painful to inject, is documented in the literature. However, few doctors actually put this knowledge into practice. With this study, we quantify this effect in the Maltese population and justify its use in our day to day practice. In addition, we take this opportunity to elaborate on the additional factors that improve patient comfort when injecting local anaesthesia.

Method

A total of 150 patients having a procedure under local anaesthesia at the Plastic Surgery and Burns Unit, at Mater Dei Hospital, Malta, were included in this study. 75 patients were injected with lidocaine alone and another 75 patients were injected with lidocaine mixed with 8.4% sodium bicarbonate.

Results

The commonest age group was the 70-79 age group in both cohorts. The minimum pain score was 0 in both groups. The highest score was 9 in the group without sodium bicarbonate and 8 in the group with sodium bicarbonate. The mean pain score was 3.93 in the cohort without sodium bicarbonate and 2.55 in the cohort with sodium bicarbonate. The median value was 4 in the group of patients injected without sodium bicarbonate and 2 in the group injected with sodium bicarbonate. The *p-value* was <0.05 , making these results statistically significant.

Conclusion

Alkalinisation of local anaesthetic solutions improves the pain of infiltration of the local anaesthetic at a minimal cost. This increases patient compliance and patient comfort and thus allowing more surgeries to be performed under local anaesthesia.

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The beneficial effect of adding 8.4% sodium bicarbonate (NaHCO_3) to local anaesthesia, making it less painful to inject is documented in the literature. However few doctors actually put this knowledge into practice. In some cases, the pain during injection of local anaesthesia is so severe, that although it is short lived, deters the patient from doing any future surgery under local anaesthesia.¹⁻⁸ This increases the risks from general anaesthesia and also the financial burden on the hospital. With this study, we quantify this effect in the Maltese population and justify its use in our day to day practice. In addition, we take this opportunity to elaborate on the additional factors that improve patient comfort when injecting local anaesthesia.

METHOD

Approval to proceed with this study was obtained from the Chairman of Surgery, the CEO, the Legal Officer and the Data Protection Officer at Mater Dei Hospital Malta where it was carried out. Ethical clearance was obtained and all the patients gave verbal consent to be included in the study. The patients were approached to be included in the study only after the procedure was done so as to avoid possible effects resulting from patient/doctor power dynamics. A total of 150 patients having a procedure under local anaesthesia at the Plastic Surgery and Burns Unit at Mater Dei Hospital Malta were included in this single-blinded study. 75 patients were injected with lidocaine alone and another 75 patients were injected with lidocaine mixed with 8.4% NaHCO_3 . The patients did not know in which arm of the study they were part of. The mixture that the second cohort were injected with, was composed of 9mls of lidocaine and 1ml of 8.4% NaHCO_3 . The patients included in the study were consecutive patients that had surgery done under local anaesthesia. There were no exclusion criteria. The local anaesthetic was

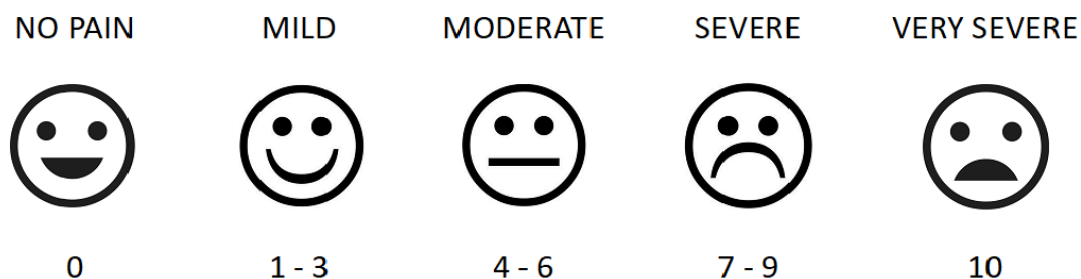
injected by a CT1 grade or higher, small needles were used and the anaesthetic was injected slowly. The temperature of the anaesthetic was brought up to body temperature as much as possible. After the surgery, the patients were asked the same formulated question, asking them to quantify the pain of injection of the anaesthetic, excluding the insertion of the needle with which the anaesthetic was given. This was done with the help of the visual analogue scale shown in [Figure 1](#).

The data obtained included: gender, age, area injected, presence of diabetes or fibromyalgia, other comorbidities affecting perception of pain including previous surgery at same site, expertise of injector, pain score and whether the anaesthetic was mixed with 8.4% NaHCO_3 or not. This information was inputted anonymously in an excel sheet and analysed using a one tailed, two sample, unequal variance t-test.

RESULTS

Seventy-five patients were considered in each cohort – local anaesthetic with NaHCO_3 was injected in one group while subjects in the other group received local anaesthetic without NaHCO_3 . The commonest age group was 70 – 79 in the cohort with local anaesthetic without NaHCO_3 , while the commonest age range of the other group was 60 - 69 years. [Table 1](#) summarises the characteristics of all included subjects, namely gender, age, comorbidity and pain score. Three of these characteristics – gender, age and pain score – were found to be statistically significant in relation to the local anaesthetic solution used with p -value <0.05 indicating that local anaesthetic with bicarbonate addition has a direct relationship to gender, age and pain score.

The average pain scores for [Figure 2](#) exhibits mean and 95% confidence intervals (CI) achieved from the



[Figure 1](#) Pain Visual Analogue Score

Table 1 Characteristics of subjects including gender, age, past medical/surgical history and pain score. P values correspond to overall comparison of row variables (Gender, Age, Past Medical/Surgical History, Pain Value) in comparison to column variables (use of local anaesthetic with or without bicarbonate). Values do not represent comparison of specific groups within each variable.

| | Without bicarbonate | With bicarbonate | p value |
|--|---------------------|------------------|----------|
| Gender | | | |
| Male | 39 | 44 | <0.00001 |
| Female | 36 | 31 | |
| Age (years) | | | |
| 0 – 9 | 0 | 0 | <0.00001 |
| 10 – 19 | 4 | 2 | |
| 20 – 29 | 6 | 8 | |
| 30 – 39 | 4 | 10 | |
| 40 – 49 | 8 | 8 | |
| 50 – 59 | 12 | 9 | |
| 60 – 69 | 14 | 13 | |
| 70 – 79 | 19 | 16 | |
| 80 – 89 | 7 | 8 | |
| 90 – 99 | 1 | 1 | |
| Past Medical/Surgical History | | | |
| Diabetes Mellitus | 6 | 7 | 0.37 |
| Fibromyalgia | 1 | 0 | |
| Stroke affecting site of surgery | 0 | 1 | |
| Previous surgery at same site | 2 | 5 | |
| Others: Stage 2 lymphoma, Multiple sclerosis | 2 | 0 | |
| Nil | 64 | 62 | |
| Pain Value | | | |
| 0 (least) | 9 | 18 | 0.018 |
| 1 | 4 | 9 | |
| 2 | 9 | 15 | |
| 3 | 7 | 12 | |
| 4 | 11 | 2 | |
| 5 | 19 | 11 | |
| 6 | 5 | 4 | |
| 7 | 6 | 3 | |
| 8 | 4 | 1 | |
| 9 | 1 | 0 | |
| 10 (most) | 0 | 0 | |

two cohorts. [Table 2](#) further explains the median, standard deviation, minimum and maximum in both groups. The *p*-value from this data is also <0.05, confirming the difference between the two cohorts to be statistically significant.

The average pain scores of specific age groups, gender and medical conditions with or without bicarbonate are exhibited in [Table 3](#).

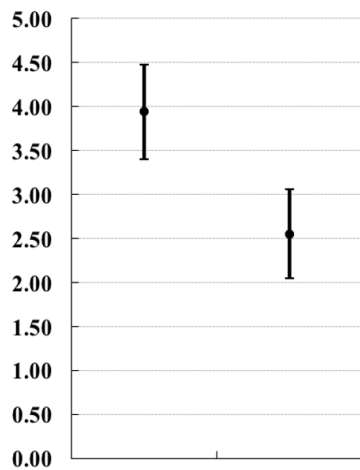


Figure 2 The mean and 95% CI for both cohorts

Table 3 Average pain scores for gender, age and patients' comorbidities for use of local anaesthetic with or without addition of bicarbonate

| | Without bicarbonate | With bicarbonate |
|--|---------------------|------------------|
| Gender | | |
| Male | 3.77 | 2.41 |
| Female | 4.11 | 2.74 |
| Age (years) | | |
| 0 – 9 | N/A | N/A |
| 10 – 19 | 5.50 | 3.00 |
| 20 – 29 | 3.83 | 1.67 |
| 30 – 39 | 3.50 | 3.00 |
| 40 – 49 | 4.00 | 3.00 |
| 50 – 59 | 3.42 | 3.00 |
| 60 – 69 | 3.86 | 3.00 |
| 70 – 79 | 4.89 | 3.00 |
| 80 – 89 | 2.63 | 3.00 |
| 90 – 99 | 0.00 | 3.00 |
| Past Medical/Surgical History | | |
| Diabetes Mellitus | 3.17 | 4.43 |
| Fibromyalgia | 6.00 | N/A |
| Stroke affecting site of surgery | N/A | 8.00 |
| Previous surgery at same site | 4.50 | 4.20 |
| Others: Stage 2 lymphoma, Multiple sclerosis | 7.00 | N/A |

Table 2 The mean, median, standard deviation, minimum and maximum for both samples

| | Without bicarbonate | With bicarbonate |
|--------------------|---------------------|------------------|
| n | 75 | 75 |
| Mean | 3.93 | 2.55 |
| Median | 4.00 | 2.00 |
| Standard deviation | 2.34 | 2.18 |
| Minimum | 0.00 | 0.00 |
| Maximum | 9.00 | 8.00 |

DISCUSSION

Local anaesthetics are basic solutions that have a pKa which is similar to the normal extracellular pH of the human cells. Lidocaine has a pKa of 7.9, which compares well to the normal extracellular pH of 7.4. This solution exists in two forms: The charged form (BH⁺) and the basic uncharged form (B), as shown in the equation below.



Half of the drug is in the charged form and the other half is in the uncharged form, when the pH is equal to the solutions' pKa. Only the uncharged lipophilic

form will diffuse across lipid barriers, such as the perineural sheath and the cell membrane. The charged hydrophilic form will move across tissue fluid barriers, such as interstitial fluid.

The local anaesthetic acts at the cytoplasmic end of the sodium channel that is present in the cell membrane. The molecules move from the outside of the cell and across the nerve cell membrane in the uncharged form (B), to then re-equilibrate on the inside of the cell, within the cytoplasm. This allows both of the forms (B and BH⁺) to be present again. Then the charged form (BH⁺) attaches to its receptor on the cytoplasmic end of the transmembrane sodium channel. This results in a conformational change in the channel protein which blocks the passage of sodium ions into the cell. When enough length of an unmyelinated nerve is impaired by this action, an action potential in that axon is inhibited. For a myelinated nerve, on the other hand, the sodium channels are found at the nodes of Ranvier. The sodium channels in many nodes of Ranvier situated near each other along the axon, need to be inhibited so as to stop the transmission of an action potential.

Commercially available local anaesthetic drugs have a pH typically between 3.5 and 5.5. This is to increase their shelf life to around three to four years.⁶ This pH level helps to slow down aldehyde formation, photo degradation, and other reactions that affect the non-ionized molecules.² Hydrochloric acid is put in the anaesthetic solution to obtain this low pH. Local anaesthetic solutions with adrenaline are usually at a lower pH than the solutions without adrenaline and so, they are more painful to inject. This is because the adrenaline is more stable at a lower pH.⁶

By neutralising these acidic solutions with 8.4% NaHCO₃, the pain during injection of the local anaesthetic is improved, without affecting the duration of anaesthesia.² This occurs because buffering the anaesthetic solution, brings the pH closer to the physiological level of pH 7.0 to pH 7.4.

The non-ionized form of the amide local anaesthetic solutions is only slightly hydrophilic, limiting how basic the local anaesthetic solution can be, before it precipitates.⁵ Precipitation has occurred when the

SUMMARY BOX

What is already known:

- It is well documented in the literature that the addition of sodium bicarbonate to local anaesthetic makes it less painful to inject.
- This practice is not widely used among non-anaesthetic doctors in Malta.
- Many surgeries are done under local anaesthetic.

What are the new findings:

- Adding sodium bicarbonate to local anaesthetic makes it less painful to inject also in the Maltese population.
- This practice makes our patients more comfortable and more complaint.
- Adding sodium bicarbonate to our local anaesthetic is financially justifiable in our day to day practice.

solution becomes cloudy. Precipitation also increases with time so the solutions should be freshly prepared. The recommended mixture of amide anaesthetic and 8.4% NaHCO₃ is shown in [Table 4](#).^{4,6}

In addition to adding 8.4% NaHCO₃ to local anaesthetic, there are many other cumulative factors that can make local anaesthetic injection less painful. These include: applying an anaesthetic cream prior to injection, using a regional nerve block technique, using a small needle, injecting the local anaesthetic slowly, warming up the local anaesthetic to body temperature prior to injection⁵, antegrade infiltration, puncturing the skin at 90 degrees to intersect less nerve endings and injecting a bolus of anaesthetic subdermally before infiltration. This alleviated the pain coming from the needle being in the skin.⁸ Moreover one should inject subdermally rather than intradermally when possible and use the smallest volume of anaesthetic possible.⁷ Perception of pain is influenced by the patients' anxiety level.⁵ Thus it is also of utmost important to make the patient feel at ease prior to injecting.

An entire local anaesthetic operating list consisting of around 10 patients, can be done utilising only one or two 10ml vials of 8.4% NaHCO₃ at the cost of around ten Euro each. Mixing the local anaesthetic with the 8.4% NaHCO₃ did not increase the time taken to finish the operating list.

Table 4 Dosage for alkalinisation of anaesthetic solutions

| Anaesthetic Solution | Volume of 8.4% NaHCO ₃ to be added to 10mls of anaesthetic |
|---------------------------|---|
| Lidocaine 1% or 2% | 1ml |
| Bupivacaine 0.25% or 0.5% | 0.05mls |

The antibacterial properties of lignocaine have also been documented. Moreover the addition of 8.4% NaHCO₃ increases this antibacterial effect that has been described for lignocaine on its own.⁹ Thus it might be that at times, we are unable to culture organisms from tissue specimen sent for culture because the tissue was exposed to lignocaine that was alkalinized with NaHCO₃.

Limitations of this study include the fact the it is single blinded and that the data collection was carried out by the same doctors caring for the patients.

CONCLUSION

Alkalinisation of local anaesthetic solutions with 8.4% NaHCO₃ significantly improves the pain of infiltration of local anaesthetic solutions at a minimal cost. This increases patient compliance and patient comfort and thus allowing more surgeries to be performed under local anaesthesia.

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