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Clinical impact of bicarbonate-buffered lidocaine on pain during tunneled catheter placement

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ABSTRACT

Aims: Numerous studies have reported the efficacy of bicarbonate-buffered lidocaine solutions in reducing injection pain. In our study, we aimed to examine the difference in injection pain scores between buffered and unbuffered lidocaine solutions during subcutaneous injection, perivascular injection, and injection along the tunnel line during the tunneling dialysis catheter placement procedure.

Methods: This retrospective observational study included 101 patients who underwent tunneled central venous hemodialysis catheter placement between January 2023 and June 2024. Clinical data were obtained through retrospective review of patient medical records.The patients included in the study were divided into two groups based on the content of the local anesthetic solution used during the procedure. The first group (n=53) consisted of patients who received local anesthesia with a 1% lidocaine solution only, while the second group (n=48) consisted of patients who received a solution of 1% lidocaine buffered with 8.4% sodium bicarbonate at a 9:1 ratio. Pain levels were recorded using a visual analog scale (VAS). Age, gender, and VAS scores were compared between groups.

Results: The age range of the 101 patients included in the study was between 19 and 84 years, and there was no significant difference in the mean age between the two groups. The gender distribution also did not show any statistically significant differences. In the comparison of VAS scores, the subcutaneous, perivascular, and tunnel region VAS scores for patients in group 1 (unbuffered) were 4.7±1.3, 4.4±1.2, and 4.2±1.5, respectively, while those in group 2 (buffered) were 2.6±1.1, 2.9±1.4, and 3.1±1.2, respectively. The difference between the groups was significant for all three injection sites, with p-values of <0.001, <0.001, and 0.002, respectively.

Conclusion: Buffered lidocaine significantly reduced injection pain in each region subcutaneous, perivascular, and tunnel line injections during the tunneled dialysis catheter placement procedure.

Keywords: Buffered lidocaine, dialysis catheter, pain level

INTRODUCTION

Local anesthetic agents play a fundamental role in ensuring patient comfort and enhancing the success of many diagnostic and interventional procedures in daily practice. However, the pain caused by local anesthetics administered before the procedure is described by most patients as the most painful part of the procedure.[1] This can cause anxiety in some patients, leading to refusal of the procedure or a request for general anesthesia.[2]

Lidocaine is the most commonly used local anesthetic agent and has acidic properties. Due to its acidic nature, it causes pain during injection.[3] To reduce the pain associated with this property of lidocaine, it is emulsified with sodium bicarbonate to increase its pH, a process known as buffering. While the resulting solution reduces the pain-inducing effect, it also increases the onset speed of lidocaine's action.[4] Similar results with buffered lidocaine have been reported in the literature for interventional procedures performed in different anatomical regions. Welch et al.[5] before periocular surgery, Hockett et al.[6] in patients undergoing percutaneous liver biopsy during both intradermal and liver capsule injections, and Vasan et al.[7] during breast biopsy procedures-particularly during intraparenchymal injection-reported that the use of buffered lidocaine significantly reduced injection pain.

In contrast, Carrine et al.[8] in infiltration anesthesia prior to vulvar biopsy, and Culp et al.[9] during central venous catheter placement procedures, found no statistically significant difference in pain scores perceived during injection between buffered and non-buffered lidocaine at the stages of subcutaneous injection and catheter placement.

Numerous studies in the literature have reported the efficacy of buffered lidocaine solutions in reducing injection pain. However, some studies have also shown that this effect is not statistically significant. To more accurately assess the effect of

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buffered lidocaine in different anatomical regions, large-scale clinical studies with control groups are needed.

In our study, we aimed to investigate the difference in injection pain levels between buffered and unbuffered lidocaine solutions during subcutaneous injection, perivascular injection, and injection along the tunnel line during the placement of a tunneled dialysis catheter.

METHODS

Ethics

This observational study was conducted using data obtained from the retrospective analysis of patient medical records, following approval by the Scientific Researches Ethics Committee of University of Health Sciences Trabzon Faculty of Medicine (Date: 27.05.2025, Decision No: 2025/211). Written informed consent was obtained from all patients as part of the standard clinical workflow for interventional procedures. Pain assessment was performed within the scope of routine clinical patient care. All procedures were performed in accordance with ethical rules and the principles of the Declaration of Helsinki.

Patient Selection and Groups

A total of 101 patients who underwent tunnelled central venous hemodialysis catheter placement in the Interventional Radiology Unit of our hospital between January 2023 and June 2024 were retrospectively analyzed.

Inclusion criteria for this study included adult patients with chronic renal failure undergoing regular hemodialysis treatment who had indications for tunneled central venous catheter placement; were conscious and fully cooperative prior to the procedure; and had no clinical or allergic contraindications to local anesthesia. Exclusion criteria included known allergy or intolerance to lidocaine or sodium bicarbonate, age under 18 years, mental disability or neurological or psychiatric condition preventing communication, impaired consciousness, active sepsis or local infection, severe coagulopathy (INR >1.5 or platelet count <50,000/mm^3), or being under anticoagulant therapy, which carries a high risk of bleeding.

Patients included in the study were divided into two groups based on the composition of the local anesthetic solution used during the procedure. The first group (n=53) consisted of patients who received local anesthesia with only a 1% lidocaine solution and used an unbuffered solution. The second group (n=48) consisted of patients who received a buffered solution obtained by mixing 1% lidocaine with 8.4% sodium bicarbonate at a 9:1 ratio. These solutions were prepared separately in sterile syringes prior to the procedure and delivered to the administering physician.

Procedure Protocol

All procedures were performed by the same team of two experienced interventional radiologists, in accordance with our unit's standard protocol. Bedside monitoring was provided during the procedures, and aseptic techniques were strictly adhered to. All procedures were performed under ultrasound (USG) and fluoroscopy guidance.

During the tunneled catheter placement procedure, the local anesthetic solution was injected into three separate anatomical areas. First, an injection was made into the skin and subcutaneous tissue at the catheter insertion site. Next, local anesthetic was applied to the soft tissues surrounding the internal jugular vein (perivascular area). Finally, anesthetic solution was injected along the trace where the catheter would extend under the skin.

The buffered solutions were prepared by mixing 9 ml of 1% lidocaine with 1 ml of 8.4% sodium bicarbonate before each procedure and administered in a single dose with the same syringe. To prevent precipitation during preparation, the bicarbonate was added last, and the mixture was administered to the injection site as quickly as possible. All injections were performed using 25G Gauge, 25 mm long intradermal injection needles (Figure).

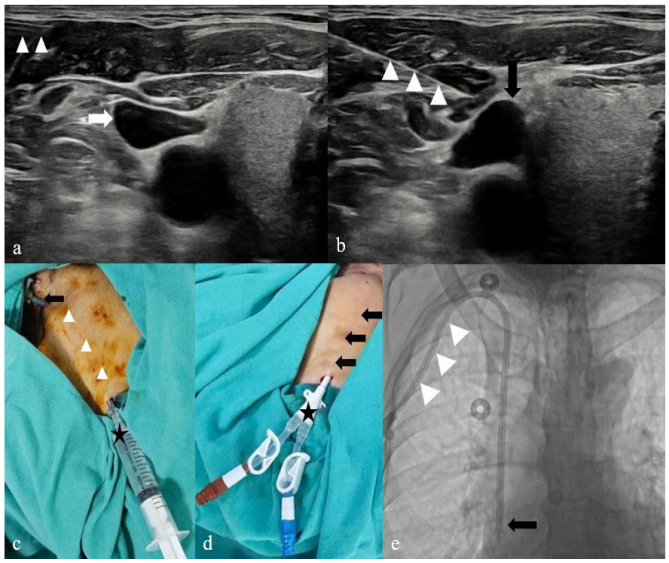

Figure. 1a. Distal cut of the needle of the syringe used for subcutaneous injection (White arrowheads). Jugular vein (White arrow). 1b. Needle of the syringe for perivascular local injection (White arrowheads). Jugular vein (Black arrow). 1c. Subcutaneous tunnel line where local anaesthetic is applied (White arrowheads). Syringe filled with local anaesthetic (Black star). 1d. Projection area of the tunnel line of the dialysis catheter with tunnel (Black arrows). Tunneled dialysis catheter (Black star). 1e. Fluoroscopic view of the tunnelled dialysis catheter. Tunnel line (White arrowheads). Tunneled dialysis catheter tip extending into the right atrium (Black arrow).

Pain Assessment

The degree of pain experienced during the local anesthetic application to each anatomical region was recorded according to the VAS score after the procedure as part of routine clinical patient care. This assessment was performed sequentially after subcutaneous injection, perivascular (around the vein) injection, and tunnel line injection.

Pain levels were recorded using a VAS rated from 0=no pain to 10=unbearable pain. The assessment was conducted immediately after the procedure by the same independent interventional radiologist for all patients.

Informed consent was obtained from the patients prior to the procedure as part of the standard clinical workflow for interventional procedures.The interventional radiologists performing the procedure were blinded to the composition of the solution used, and the physician performing the procedure was not involved in the VAS measurement process in any way, thus avoiding systematic bias.

Statistical Analysis

All statistical analyses were performed using the SPSS Statistics v25.0 (IBM, NY, USA) program. Continuous variables are presented as mean±standard deviation, while categorical variables are presented as counts and percentages (%). The normality of continuous variables was assessed using the Kolmogorov-Smirnov test. For intergroup comparisons, the independent samples t-test was used for continuous variables, and the Chi-square test was used for categorical variables. A $p<0.05$ value was considered statistically significant.

RESULTS

The ages of the 101 patients included in the study ranged from 19 to 84 years, and there was no significant difference in the mean age between the two groups. The mean age in group 1 (unbuffered lidocaine) was 61.7±11.3 years, while the mean age in group 2 (buffered lidocaine) was 63.2±10.1 years (p=0.46). The gender distribution also showed no statistically significant difference; group 1 included 30 males (56.6%) and 23 females (43.4%), while group 2 included 26 males (54.2%) and 22 females (45.8%) (p=0.81).

The patients' hemodialysis history and previous vascular access procedures for dialysis were also examined. The total dialysis duration was calculated as 3.±2.1 years on average in group 1 and 4.2±1.9 years in group 2, with no significant difference observed between the two groups (p=0.38). When comparing the number of vascular interventions, it was determined that patients in group 1 had an average of 1.7±0.8 AV fistulas and 1.9±0.6 dialysis catheters. In group 2, these values were 1.6±0.7 (AV fistula) and 2.3±0.5 (non-tunneled catheter), respectively, and the difference between the groups was not statistically significant (p>0.05).

Demographic and clinical characteristics are summarized in Table 1.

Table 1. Demographic and clinical characteristics table

	Group 1 (unbuffered)	Group 2 (buffered)	p-value
Average age (years)	61.7±11.3	63.2±10.1	0.46
Gender (male/female)	30/23	26/22	0.81
Average dialysis duration (years)	3.9±2.1	4.2±1.9	0.38

Procedure Duration

The duration of the catheter placement procedure was similar in both groups. The mean procedure duration was 27.3±5.6 minutes in Group 1 and 26.1±4.8 minutes in Group 2, and the difference between the groups was not statistically significant (p=0.19). This result indicates that the use of buffered solution does not prolong the procedure time.

Pain Assessment

Pain scores obtained after local anesthesia administered at three separate anatomical levels were found to be significantly lower in the buffered lidocaine group. VAS scores are summarized in Table 2.

Table 2. VAS score results according to procedure sites

Injection site	Group 1-unbuffered (n=53)	Group 2-buffered (n=48)	p-value
Subcutaneous	4.7±1.3	2.6±1.1	<0.001
Perivascular	4.4±1.2	2.9±1.4	<0.001
Tunnel zone	4.2±1.5	3.1±1.2	0.002

VAS: Visual Analog Scale

In the group receiving buffered lidocaine, pain levels were found to be statistically significantly lower during the tunnel creation phase, along with subcutaneous and perivascular injections.

Complications

No major procedure-related complications developed in either group. Localized hematoma was observed in the procedure area in three patients (2.9%), but it resolved spontaneously without requiring additional treatment. Two of these patients were in group 1 and one was in group 2. No allergic reactions to local anesthetics or sodium bicarbonate were observed in any case.

DISCUSSION

Our study demonstrated that the use of a buffered solution prepared at a 1:9 ($NaHCO_3$: Lidocaine) ratio during subcutaneous, perivascular, and tunnel line local anesthetic injections in tunneled hemodialysis catheter placement significantly reduced pain levels compared with unbuffered lidocaine. The underlying mechanism is thought to be a reduction in the sensation of “burning and pain” during injection due to the increased pH of the local anesthetic solution. In addition, a shortened onset time of lidocaine was identified as another important contributing factor.[10,11,12]

Randomized studies conducted in different interventional procedure sites have demonstrated that buffered lidocaine reduces injection-related pain.[10,13] In intradermal anesthesia and during inferior alveolar nerve block, buffering has been shown to be effective in reducing pain and accelerating the onset of action.[12,14] Overall, the literature supports that buffered local anesthetic agents can be applied across a wide range of clinical settings. In our study, the significant reduction in pain scores observed in line with the literature further supports the effectiveness of this approach.

Data related to deep tissue or visceral organ interventions also support the effectiveness of buffering. In patients undergoing image-guided breast biopsy, lower pain scores have been

reported during intraparenchymal injection of buffered lidocaine.[7] Similar findings have been observed in visceral organ procedures such as percutaneous liver biopsy, where a marked reduction in pain during injection into the liver capsule was noted.[6] In our study, perivascular and tunnel line injections were also evaluated within the deep tissue group. Our results are consistent with the literature and support that buffering is effective not only in subcutaneous tissue but also in deep tissue injections.

A study conducted by Culp et al.,[9] which shows methodological similarities to our study, has been reported in the literature. In that study, no statistically significant difference was found in pain scores perceived during injection between buffered and unbuffered lidocaine during the stages of subcutaneous injection and catheter placement in central venous catheterization procedures. Compared with our study, tunneled catheter placement was not performed in the study by Culp et al.,[9] and therefore tunnel anesthesia and its comparison were not included. In addition, the total injection volume was 5 ml, which is substantially lower than that used in our study. More importantly, the more limited patient population in their study may have contributed to the differing results. Overall, these findings suggest that studies involving the injection of similar volumes of anesthetic agents across multiple anatomical regions may provide valuable contributions to the literature.

It has been reported that a 1:3 mixture ratio used in dermatological applications causes less injection pain in patients compared with a 1:9 ratio.[3] In contrast, 1:9 or 1:10 ratios are more commonly preferred in routine clinical practice. Indeed, Frank and Lalonde[15] emphasized that a ratio of approximately 1:10 provides the best balance between efficacy and safety for solutions containing epinephrine, whereas slightly higher amounts of bicarbonate may be tolerated in epinephrine-free solutions. The effect of epinephrine on the efficacy of buffering has also been evaluated in various clinical studies. Christoph et al.[11] assessed infiltration pain in both plain lidocaine and epinephrine-containing lidocaine solutions and demonstrated that buffering significantly reduced injection pain for both formulations. These findings indicate that epinephrine does not negate the pain-reducing effect of buffering. Similarly, Welch et al.[5] reported that buffering 2% epinephrine-containing lidocaine used for periorbital anesthesia resulted in clinically and statistically significant pain reduction. Overall, the literature suggests that the bicarbonate-to-lidocaine mixture ratio may vary depending on whether the local anesthetic contains epinephrine. Nevertheless, buffering can be considered to reliably reduce infiltration pain in both epinephrine-containing and epinephrine-free local anesthetic solutions. In our study, epinephrine-free lidocaine was used, and the mixture was prepared at a 1:9 ratio. The results obtained were consistent with the literature.

Reports of serious adverse events related to procedures performed with buffered local anesthetic solutions are rare. The key principles of safe practice include administering the mixture without delay, avoiding excessive bicarbonate addition in epinephrine-containing preparations, and being mindful of the risk of precipitation.[15,16] In our study, no solution-related adverse effects were observed. Only minor complications, such as local hematoma at the procedure sites, were identified, and these were managed with medical treatment without the need for additional interventions.

Limitations

The main limitations of our study include the relatively small sample size and the use of epinephrine-free lidocaine as the sole anesthetic option with a single buffering ratio. We believe that studies involving larger patient populations and comparing different buffering ratios would provide a more substantial contribution to the literature. Additionally, the retrospective observational design of the study should be considered a limitation, as it may be associated with potential selection bias.

CONCLUSION

As a result, our findings show that buffered lidocaine significantly reduces injection pain in each area-subcutaneous, perivascular, and tunnel line injections-during tunneled catheter placement. Consistency with randomized trials and meta-analyses in different clinical settings suggests that 1:9 bicarbonate buffering could become a low-cost, easy-to-administer, and patient-friendly standard in epinephrine-free applications.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was conducted with the approval of the Scientific Researches Ethics Committee of University of Health Sciences Trabzon Faculty of Medicine (Date: 27.05.2025, Decision No: 2025/211).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

Concept: E.B.; Design: E.B., N.K.O.; Control: E.B., N.K.O.; Data collection and/or processing: N.K.O.; Analysis and/or interpretation: E.B.; Literature review: E.B., N.K.O.; Article writing: E.B.; Critical review: All authors.

REFERENCES

1. Alam M, Worley B. Buffered lidocaine: the standard of care for cutaneous procedures. *J Am Acad Dermatol.* 2020;83(1):166-167. doi:10.1016/j.jaad.2020.01.017

2. Golzari SE, Soleimanpour H, Mahmoodpoor A, Safari S, Ala A. Lidocaine and pain management in the emergency department: a review article. *Anesth Pain Med*. 2014;4(1):e15444. doi:10.5812/aapm.15444
3. Burns CA, Ferris G, Feng C, Cooper JZ, Brown MD. Decreasing the pain of local anesthesia: a prospective, double-blind comparison of buffered, premixed 1% lidocaine with epinephrine versus 1% lidocaine freshly mixed with epinephrine. *J Am Acad Dermatol*. 2006;54(1):128-131. doi: 10.1016/j.jaad.2005.06.043
4. Cepeda MS, Tzortzopoulou A, Thackrey M, Hudcova J, Arora Gandhi P, Schumann R. Adjusting the pH of lidocaine for reducing pain on injection. *Cochrane Database Syst Rev*. 2010;(12):CD006581. doi:10.1002/14651858.CD006581.pub2
5. Welch MN, Czyz CN, Kalwerisky K, Holck DE, Mihora LD. Double-blind, bilateral pain comparison with simultaneous injection of 2% lidocaine versus buffered 2% lidocaine for periocular anesthesia. *Ophthalmology*. 2012;119(10):2048-2052. doi:10.1016/j.ophtha.2012.05.029
6. Hockett D, Kress L, Mac Donald R, Krenzischek DA, Maheshwari A. Effectiveness of buffered lidocaine for local anesthesia during liver biopsy. *Gastroenterol Nurs*. 2021;44(3):172-176. doi:10.1097/SGA.0000000000000542
7. Vasan A, Baker JA, Shelby RA, Soo MSC. Impact of sodium bicarbonate-buffered lidocaine on patient pain during ımage-guided breast biopsy. *J Am Coll Radiol*. 2017;14(9):1194-1201. doi:10.1016/j.jacr.2017.03.026
8. Villavicencio JC, Kulkarni A, Luis C, et al. Sensation of pain using buffered lidocaine for infiltration before vulvar biopsy: a randomized controlled trial. *Obstet Gynecol*. 2020;135(3):609-614. doi:10.1097/AOG.0000000000003710
9. Culp WC Jr, Yousaf M, Lowry B, McCowan TC, Culp WC. Pain and efficacy of local anesthetics for central venous access. *Local Reg Anesth*. 2008;1:11-15. doi:10.2147/lra.s4337
10. Bartfield JM, Gennis P, Barbera J, Breuer B, Gallagher EJ. Buffered versus plain lidocaine as a local anesthetic for simple laceration repair. *Ann Emerg Med*. 1990;19(12):1387-1389. doi:10.1016/s0196-0644(05)82603-4
11. Christoph RA, Buchanan L, Begalla K, Schwartz S. Pain reduction in local anesthetic administration through pH buffering. *Ann Emerg Med*. 1988;17(2):117-120. doi:10.1016/s0196-0644(88)80293-2
12. Hanna MN, Elhassan A, Veloso PM, et al. Efficacy of bicarbonate in decreasing pain on intradermal injection of local anesthetics: a meta-analysis. *Reg Anesth Pain Med*. 2009;34(2):122-125. doi:10.1097/AAP.0b013e31819a12a6
13. Brogan GX Jr, Giarrusso E, Hollander JE, Cassara G, Maranga MC, Thode HC. Comparison of plain, warmed, and buffered lidocaine for anesthesia of traumatic wounds. *Ann Emerg Med*. 1995;26(2):121-125. doi:10.1016/s0196-0644(95)70139-7
14. Guo J, Yin K, Roges R, Enciso R. Efficacy of sodium bicarbonate buffered versus non-buffered lidocaine with epinephrine in inferior alveolar nerve block: a meta-analysis. *J Dent Anesth Pain Med*. 2018;18(3):129-142. doi:10.17245/jdapm.2018.18.3.129
15. Frank SG, Lalonde DH. How acidic is the lidocaine we are injecting, and how much bicarbonate should we add?. *Can J Plast Surg*. 2012;20(2):71-73. doi:10.1177/229255031202000207
16. Vent A, Surber C, Graf Johansen NT, et al. Buffered lidocaine 1%/epinephrine 1:100,000 with sodium bicarbonate (sodium hydrogen carbonate) in a 3:1 ratio is less painful than a 9:1 ratio: a double-blind, randomized, placebo-controlled, crossover trial. *J Am Acad Dermatol*. 2020;83(1):159-165. doi:10.1016/j.jaad.2019.09.088