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Original article

Buffered *versus* Non-Buffered Local Anesthesia in Septorhinoplasty: A Comparative Assessment of Injection Pain and Patient Satisfaction

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Abstract
Rhinoplasty is among the most common facial aesthetic procedures. Although general anesthesia is the conventional standard, local anesthesia offers significant benefits, such as diminished intraoperative bleeding and expedited postoperative recovery. A primary limitation to its broader implementation is the pain associated with the injection of local anesthetics. This study aimed to assess the efficacy of buffering local anesthetic solutions with sodium bicarbonate in reducing the intensity of injection pain and enhancing patient comfort during septorhinoplasty performed under local anesthesia. A prospective, within-subject comparative study was conducted involving 20 patients who underwent elective septorhinoplasty. Each patient received two anesthetic formulations injected into the contralateral sides of the nose: a buffered solution (Solution A: pH 7.2-7.4, with sodium bicarbonate 7.5%) and a standard, non-buffered solution (Solution B: pH 4.5-5.5). The primary outcome measures were patient-reported pain perception during injection, time to anesthetic onset, duration of anesthetic effect, and intraoperative hemostatic quality. Buffered anesthesia was associated with a statistically significant reduction in injection pain, as reported by 18 patients (90%) ($p < 0.001$). The mean pain score for the buffered solution was 2.8 ± 1.4, compared to 5.7 ± 1.9 for the non-buffered solution, constituting a 51% reduction. A non-significant trend toward a faster onset of anesthesia was observed with the buffered solution (8.4 ± 2.6 minutes vs. 10.1 ± 3.4 minutes, $p = 0.09$). No statistically significant differences were identified between the two solutions regarding the duration of anesthesia (178 ± 24 minutes vs. 182 ± 27 minutes, $p = 0.62$) or hemostatic efficacy. The buffering of local anesthetics with sodium bicarbonate significantly attenuates injection-related pain in patients undergoing septorhinoplasty, without compromising anesthetic duration, hemostatic quality, or safety. The adoption of this technique is recommended to optimize patient comfort in rhinoplasty procedures utilizing local anesthesia.
Keywords: Rhinoplasty, Local Anesthesia, Buffered Anesthetic, Pain Reduction.

Introduction

Rhinoplasty is consistently ranked among the most frequently performed facial plastic surgery procedures globally, with a sustained high procedural volume [1-3]. The surgery is uniquely positioned to address both functional impairments, such as nasal obstruction from septal deviation, and aesthetic concerns related to nasal shape and projection [4]. While general anesthesia has been the traditional mainstay for rhinoplasty, the paradigm is shifting towards the use of local anesthesia with sedation, a practice gaining prominence due to its distinct benefits [5]. These advantages include superior intraoperative hemostasis from the vasoconstrictive effects of epinephrine, a more favorable recovery profile with fewer anesthetic-related side effects, and increased cost-effectiveness for surgical facilities [6, 7].

A significant barrier to the wider adoption of local anesthesia, however, is the considerable pain patients experience during the injection of the anesthetic solution [8]. This discomfort is largely attributable to the low pH (approximately 3.5-5.5) of commercially prepared local anesthetics, which is necessary for chemical stability and solubility of the hydrochloride salts but causes significant tissue irritation upon injection [9, 10]. Buffering these acidic solutions with sodium bicarbonate ($NaHCO_3$) to a more physiological pH (7.2-7.4) has been proposed as a method to mitigate this pain [11]. The underlying mechanism is twofold: first, it directly reduces chemical irritation of the tissues, and second, it increases the proportion of the non-ionized, lipophilic form of the drug, which theoretically enhances diffusion through nerve sheaths and may accelerate the onset of action [10, 12]. Although this technique has demonstrated efficacy in reducing injection pain in other clinical contexts such as dermatology and dentistry, its application and systematic evaluation in the specific setting of rhinoplasty remain limited [11, 13]. Therefore, this prospective comparative study was designed to rigorously evaluate the hypothesis that buffering local anesthetic with sodium bicarbonate significantly reduces injection-related pain and improves patient comfort during septorhinoplasty, without compromising anesthetic duration or hemostatic quality.

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Methods

Study Design and Population

This prospective, comparative, within-subject study was conducted between January 2022 and April 2023 at the Plastic Surgery Units of the National Cancer Institute and Alhelal University Hospital in Misrata, Libya.

The study population consisted of twenty patients scheduled for elective septorhinoplasty. A power analysis, based on preliminary data suggesting a 40% reduction in pain scores with buffered anesthesia, determined a minimum requirement of 17 patients ($\alpha = 0.05$, power = 0.80, effect size = 0.8); twenty were enrolled to account for potential dropouts. Eligible patients were aged 18 to 65, classified as ASA physical status I or II, and were undergoing surgery for functional or aesthetic indications. Key exclusion criteria included a known allergy to amide local anesthetics, significant systemic illness (ASA III or higher), revision surgery, pregnancy, chronic pain conditions, regular opioid use, or significant anxiety disorders.

Two local anesthetic solutions were prepared for comparison. The buffered solution (Solution A) was a combination of 5 mL of lidocaine 2% with epinephrine 1:100,000 and 5 mL of bupivacaine 0.25% with epinephrine 1:200,000, alkalized with 2 mL of sodium bicarbonate 7.5% to a final pH of 7.2-7.4 and a total volume of 12 mL. The non-buffered control solution (Solution B) consisted of 6 mL of each of the same lidocaine and bupivacaine solutions, resulting in a total volume of 12 mL with a native pH of 4.5-5.5.

Following the application of topical anesthesia with lidocaine 4% and oxymetazoline-soaked pledgets, each patient received both study solutions. The solutions were administered to opposite sides of the nose in a randomized sequence. A single anesthetist performed all injections using a 27-gauge needle at a controlled rate of 0.5-1.0 mL per 10 seconds, targeting standard nerve blocks and infiltration areas including the infratrochlear and infraorbital nerves, nasal dorsum, tip, septum, and turbinates.

The primary outcome measure was immediate post-injection pain, assessed using a direct comparison question ("Which side was more painful?") and an 11-point Numerical Rating Scale (NRS). Secondary outcomes included the onset time of anesthesia, determined by pinprick testing at 2-minute intervals; the total duration of surgical anesthesia; hemostatic quality as rated by the surgeon on a 4-point scale; overall patient comfort and cooperation; and the incidence of any adverse events.

Ethical approval

The study protocol received institutional ethical approval, and all participants provided written informed consent prior to enrollment. The investigation was carried out in accordance with the principles of the Declaration of Helsinki guidelines.

Statistical analysis

For statistical analysis, data were analyzed using SPSS version 26.0. Categorical variables were compared using the chi-square or Fisher's exact test, while continuous variables were analyzed with paired t-tests. Ordinal data, including the NRS scores, were compared using the Wilcoxon signed-rank test. A p-value of less than 0.05 was defined as statistically significant.

Results

All twenty enrolled patients (8 females, 12 males) completed the study. The cohort's mean age was 32.4 ± 8.7 years, with the majority (70%) classified as ASA physical status I. The primary surgical indications were aesthetic concerns (55%), functional nasal obstruction (25%), or a combination of both (20%). The mean procedural duration was 142 ± 28 minutes. Detailed baseline characteristics are presented in Table 1.

Table 1. Baseline Characteristics of the Study Population (N=20)

Characteristic	Value
Age (years) mean ± SD	32.4 ± 8.7
Sex N (%)	
Male	12 (60%)
Female	8 (40%)
ASA Physical Status, n (%)	
I	14 (70%)
II	6 (30%)
Surgical Indication, n (%)	
Aesthetic	11 (55%)
Functional	5 (25%)
Combined	4 (20%)
Procedure Duration (min), mean ± SD	142 ± 28

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A statistically significant majority of patients reported a marked reduction in injection pain with the buffered anesthetic solution. When asked to directly compare the two sides, 90% of patients (n=18) identified the buffered solution as less painful ($p < 0.001$). The distribution of patient preferences is illustrated in Figure 1.

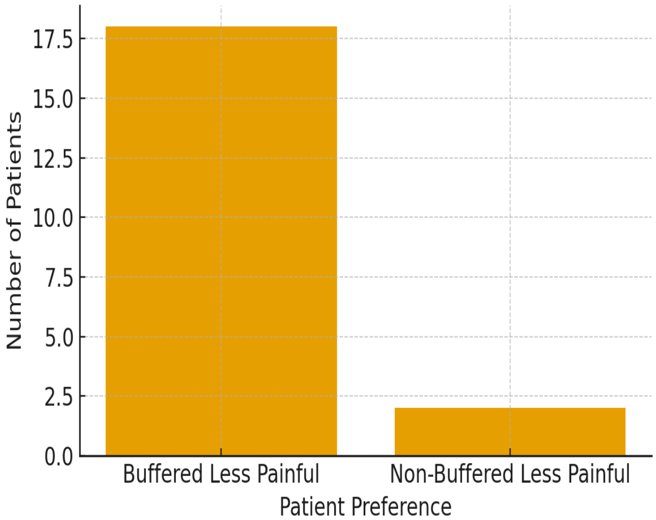

Figure 1. Patient Preference for Anesthetic Solution Based on Direct Comparison

Quantitative assessment using the Numerical Rating Scale (NRS) corroborated these findings. The mean pain score for the buffered solution (2.8 ± 1.4) was significantly lower than for the non-buffered solution (5.7 ± 1.9), with a mean difference of 2.9 points (95% CI: 2.1 to 3.7; $p < 0.001$). This represents a 51% reduction in perceived pain intensity. A comparison of the pain score distributions is shown in Figure 2.

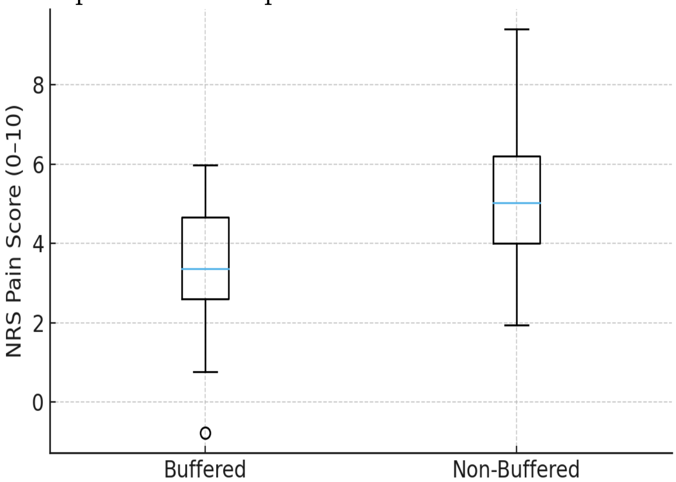

Figure 2. Distribution of Pain Scores (NRS) for Buffered vs. Non-Buffered Anesthesia.

The comparative data for secondary outcomes, including anesthetic properties and hemostatic efficacy, are summarized in Table 2.

Table 2. Comparison of Secondary Outcomes Between Anesthetic Solutions

Outcome	Buffered Solution (mean ± SD)	Non-Buffered Solution (mean ± SD)	P-value
Onset Time (min	8.4 ± 2.6	10.1 ± 3.4	0.09
Duration of Anesthesia (min)	178 ± 24	182 ± 27	0.62
Hemostatic Quality, n (%)			
Excellent	17 (85%)	16 (80%)	0.56
Good	3 (15%)	4 (20%)	
Patient Comfort, n (%)			
Excellent	14 (70%)	14 (70%)	N/A
Good	6 (30%)	6 (30%)	

Regarding patient tolerance, all cases were rated as having excellent (70%) or good (30%) cooperation. Notably, 80% of patients (n=16) provided unsolicited feedback that the less painful initial injection on the buffered side significantly improved their overall cooperation.

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No serious adverse events were recorded. The observed minor events were transient and similar between groups, including one vasovagal response (5%), two cases of mild prolonged numbness (10%), and three cases of expected periorbital ecchymosis (15%).

Discussion

study demonstrates that buffering local anesthetic solutions with sodium bicarbonate significantly reduces injection pain during septorhinoplasty, achieving a 51% reduction in pain scores, while maintaining equivalent anesthetic duration and hemostatic efficacy. This represents a clinically meaningful improvement that directly addresses a primary barrier to patient acceptance of procedures under local anesthesia.

The physiological mechanism underlying this marked pain reduction is well-explained by pH-dependent pharmacology. Commercial preparations of local anesthetics are intentionally acidic (pH 3.3-5.5) to ensure chemical stability and prolong the shelf-life of the added epinephrine. However, this low pH directly activates tissue nociceptors, causing the characteristic burning sensation upon injection [10]. More critically, the acidic environment favors the ionized (charged) form of the anesthetic molecule, which is hydrophilic and diffuses poorly across the lipid nerve membrane [4, 11]. The neutralization of the solution raises the pH toward a more physiological range. This has a dual benefit: it reduces direct chemical irritation of nociceptors and dramatically shifts the equilibrium toward the membrane-permeable, non-ionized form. For instance, increasing the pH from 4.5 to 7.2 increases the non-ionized fraction of lidocaine from approximately 0.2% to 24%, a more than 100-fold enhancement in the drug's ability to penetrate the nerve [12].

Our findings are consistent with a body of previous research that has demonstrated pain reduction with buffered anesthetics across various surgical and emergency medicine contexts [8, 13, 14]. The observed trend toward a faster onset of anesthesia with the buffered solution, while not statistically significant in our cohort, aligns with the theoretical expectation of enhanced nerve penetration. The equivalent duration of action and hemostatic quality between the two solutions confirms that the fundamental efficacy of the anesthetic block is not compromised by buffering.

The routine incorporation of buffering techniques presents a straightforward method to significantly enhance the patient experience in rhinoplasty under local anesthesia. The simple addition of 2 mL of sodium bicarbonate 7.5% to standard anesthetic mixtures provides substantial benefit without introducing significant cost or complexity. To prevent potential precipitation and ensure epinephrine stability, solutions should be prepared fresh and used within 10 minutes of mixing.

Several limitations of this study warrant consideration. The sample size, though sufficient for the primary outcome, was relatively small. The single-center design and lack of long-term follow-up may limit the generalizability of the findings. While the within-subject design effectively controls for inter-individual variability, it may introduce potential order effects, despite the use of randomization. Future research involving multicenter trials with larger sample sizes could further validate these results and explore optimal buffering ratios for different anesthetic mixtures.

Conclusion

In conclusion, buffering standard local anesthetic solutions with sodium bicarbonate significantly reduces the pain of injection during septorhinoplasty without compromising anesthetic efficacy, hemostatic quality, or safety. This simple, low-cost modification directly addresses a major deterrent to local anesthesia and is strongly recommended for routine adoption in rhinoplasty and other facial plastic surgery procedures. Further investigation is warranted to refine optimal buffering protocols and to evaluate its application in other surgical domains.

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Conflict of interest. Nil

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