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Evaluation of Onset and Duration Period of Pulpal Anesthesia on Articaine, Buffered Articaine, Lignocaine and Buffered Lignocaine in Inferior Alveolar Nerve Block

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Research Article

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Abstract

Context: Pain is one of the most commonly experienced symptoms in dentistry, and managing pain is of greater importance during dental treatment. Local anesthetics are chemicals that block nerve conduction in a specific, temporary and reversible manner, without affecting the patient's consciousness.

Aims: The aim of this study is to evaluate the anesthetic efficacy of buffered lignocaine, buffered articaine, unbuffered lignocaine and unbuffered articaine in terms of latency (onset of anesthetic effect), duration of anesthetic effect during extraction of mandibular teeth following standard inferior alveolar nerve block.

Settings and Design: This study was conducted at Department of Oral and Maxillofacial Surgery, Saveetha University, Chennai from November 2013 to November 2015.

Methods and Materials: This study compares the anesthetic efficacy of 4% articaine, 2% lignocaine, 4% buffered articaine and 2% buffered articaine with epinephrine. Onset, duration of anesthetic effect was compared.

Statistical analysis used: ANOVA

Results: Total number of patients were 272. These patients were equally divided into 4 groups, each group containing 68 patients.THE anova test shows that significant difference between the groups, the mean value shows the group 4 is better than the other 3 groups.

Conclusion: We conclude that 4% articaine has faster onset when compared to the other three group. Buffered lignocaine had significantly longer duration when compared to the other groups. This can be explained based on its different chemical structure, liposolubility, increased protein binding ability, diffusion in soft tissue and increased pulpal anesthesia.

Keywords: UBuffered lignocaine; Buffered Articaine; Articaine; Lignocaine; pH

Introduction

Pain is one of the most commonly experienced symptoms in dentistry, and managing pain is of greater importance during dental treatment [1,2]. Local anesthetics are chemicals that block nerve conduction in a specific, temporary and reversible manner, without affecting the patient's consciousness [3]. Carl Koller, a junior ophthalmologist is

considered "Father of Local Anesthesia" [4]. William Halstad was the first person to use cocaine for conduction anesthesia [3]. Alfred Einhorn discovered Procaine, which marked the beginning of modern era regional anesthesia [5].

Although the patient may be told that the injection will feel "like a mosquito bite", it is often much worse. To minimize the patient's discomfort during a procedure has obvious benefits for both the patient and the surgeon. Although it is short-lived, the perceived pain of the injection of local anesthetic is bad enough for some patients to decline further interventions under local anesthesia. To give additional analgesics, or sedatives, or both, can be impractical and time consuming; it is even at times contraindicated [6].

The challenge is that while local anesthetic is the primary tool for pain management, its acidity may contribute to lengthy anesthetic waiting periods and cause the bee-sting effect or burning and stinging during the injection many of us are surprised to learn that the most widely used dental anesthetic solution are formulated at the pH of lemon juice [5].

Dental anesthetic was first studied by GRDS and then written by Laewen in 1910. Since the introduction of lidocaine in 1948, there have been dozens of studies evaluating whether alkalainisation would improve onset time or reduce injection pain. Occasionally alkalanisation has been studied in combination with warming or injection speed [7,8].

The present study compares the anesthetic efficacy on onset and duration of buffered lignocaine, unbuffered lignocaine, buffered articaine and unbuffered articaine, in application to truncal block of the inferior alveolar nerve during the extraction.

Subjects and Methods

Study Design

This prospective study was approved by the human studies review board of Saveetha Dental College, after which 272 healthy patients aged 15-80 years gave their written consent to participate. They were among patients who were to have procedure under local anaesthesia in the mandibular region.

Surgical Procedure

All 272 patients were given standard nerve blocks anaesthetising inferior alveolar, lingual and long buccal. This 272 patients were given all these nerve blocks. All patients were randomly divided into 4 groups. Each one picked a slip and had the LA according to the group allotted randomly.

One group was given lignocaine hydrocholoride with adrenaline 1:80,000 solution as LA .Second group was given 4% articaine in 1:1,00,000 solution as LA . Third group was given buffered articaine that is a total of 1 ml of 7.5% sodium bicarbonate was added to 30 ml of vial containing 4 % of articaine as LA. Fourth group was given buffered lignocaine that is a total of 7.5% sodium bicarbonate. 3ml was added to 30ml vial containing 2% lignocaine hydrochloride with 1:80,000 adrenaline solution which yields one tenth dilution.

All the patients had the procedure explained to them. Both the operators and patients were unaware of which anaesthetic the patient had given. All LA in 4 groups were given using non pyrogenic, non-toxic sterile, single use injection. A maximum of 2.5 ml solution was used for all these blocks.

The time of onset of anaesthesia is defined as the first sensation of numbness or tingling in the anaesthetised region. It was calculated from the point of retrieval of the needle after the injection. A straight probe was used to assess the onset of anaesthesia by inserting it in the gingival sulcus of the teeth in the area of anaesthesia.

Duration of anaesthetic effect was recorded via telephonic interview.

Results

Following completion of the clinical study on the patients the data taken from the patients were tabulated for statistical studies after decoding drugs used.

Total number of patients were 272. These patients were equally divided into 4 groups, each group containing 68 patients (Table 1).

	Group I (%)	Group II (%)	Group III (%)	Group IV (%)	Overall
Male	28(42.4)	32(45.1)	22(32.8)	36(52.9)	118
Female	38(57.6)	39(54.9)	45(67.2)	32(47.1)	154
Overall	68	68	68	68	272

Table 1: Basic Demographical Variables Descriptive Statistics.

Among the total participants 118 (43.4%) were male and 154 (56.6 %) were female (Table 2).

Age	Group I (%)	Group II (%)	Group III (%)	Group IV (%)	No. of Partici-pants	Percentage	Mean	SD
10-20yrs	6(9.1)	10(14.1)	6(9)	9(13.2)	31	11.4	3.03	1.46
20-30yrs	20(30.3)	21(29.6)	25(37.3)	21(30.9)	87	32		
30-40yrs	14(21.2)	17(23.9)	18(26.9)	20(29.4)	69	25.4		
40-50yrs	11(16.7)	10(14.1)	9(13.4)	8(11.8)	38	14		
50-60yrs	8(12.1)	9(12.7)	2(3)	6(8.8)	25	9.2		
60-70yrs	7(10.6)	3(4.2)	5(7.5)	2(2.9)	22	7.3		
70-80yrs	0(0)	1(1.4)	2(3)	2(2.9)				
Total	66 (24.3)	71(26.1)	67(24.6)	68(25)				

Table 2: Age Distribution of 4 Groups.

Table 2 and Figure 1 shows the more of the participants were participated at the age group of 30-40 years, the mean age and sd is 3.03±1.46.

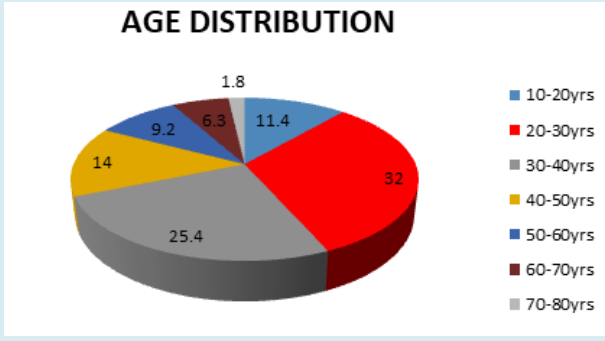

Figure 1: Age wise distribution of sample.

	Sum of squares	Df	Mean Square	F	Sig.
Between Groups	1670.99	3	556.99	278	0.000*
Within Groups	536.95	268	2		

Group	N	Mean (sec)	SD	Standard Error	95% CI	
					Lower Limit	Upper Limit
1	68	332.12	63.9	7.87	316.4	347.83
2	68	185.92	63.4	7.53	170.9	200.94
3	68	339.52	73.2	8.94	321.7	357.39
4	68	239.66	27.86	3.37	100.9	114.39

Table 3: ANOVA Test for Comparison of 4 Groups.

The anova test (Figure 2) shows that significant difference between the groups, the mean value shows the group 3 is better than the other 3 groups. The mean plot diagram also shows that group 3 is better than the other group treated with onset.

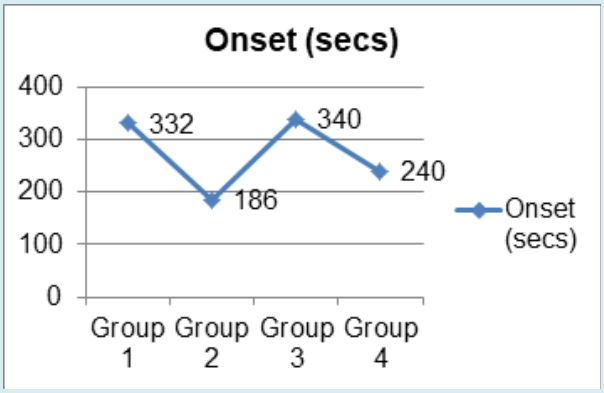

Figure 2: ANOVA Test for Comparison of 4 Groups.

Group		Mean Difference	SD Error	Sig.	95% CI	
					Lower Limit	Upper Limit
1	2	146..20	10.19	0	119.8	172.57
	3	7.4	10.34	0.891	34.14	19.34
	4	224.47	10.3	0	197.8	251.12
2	1	146.2	10.19	0	172.6	119.84
	3	153.6	10.16	0	179.9	127.34
	4	78.26	10.12	0	52.1	104.43
3	1	7.4	10.34	0.891	19.34	34.14
	2	153.6	10.16	0	127.3	179.87
	4	231.87	10.26	0	205.3	258.42
4	1	224.47	10.3	0	251.1	197.83
	2	78.26	10.12	0	104.4	52.1
	3	231.87	10.26	0	258.4	205.33

Table 4: Multiple Comparison.

There was statistically significant difference between groups as determined by anova (3,268) = 278, p=0.000. A turkey post hoc test revealed that the time to complete the problem was statistically significant higher in group 3. There was a no statistical difference between the other groups (Table 5).

	Sum of squares	Df	Mean Square	F	SIG
Between Groups	541.4	3	180.46	182.9	0.000*
Within Groups	264.41	268	0.987		

Group	N	Mean (min)	SD	Standard Error	95% CI	
					Lower Limit	Upper Limit
1	66	159	63.911	3.22	152.2	165.07
2	71	215	63.46	3.42	208.7	222.32
3	67	196	73.25	5.39	185.2	206.72
4	68	276	27.86	4.36	267	284.45

Table 5: Anova test for duration.

The anova test (Figure 3) shows that significant difference between the groups, the mean value shows the group 4 is better than the other 3 groups. The mean plot diagram also shows that group 4 is better than the other group when tested with duration.

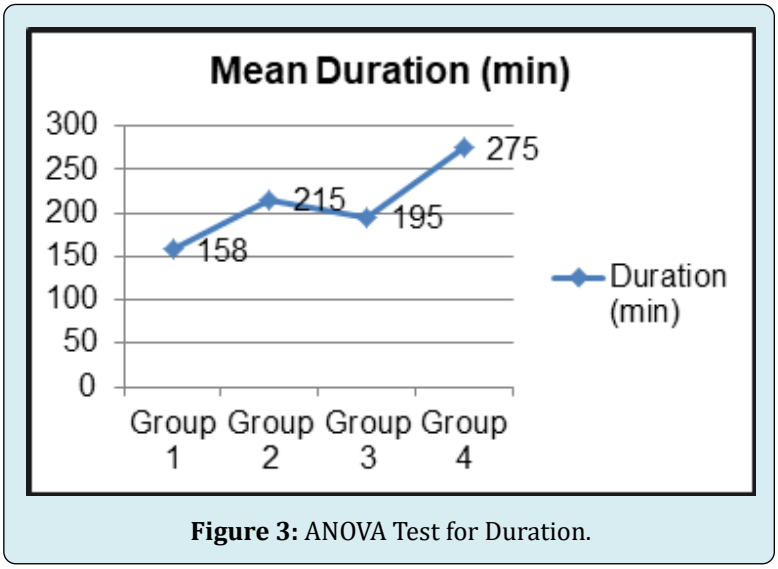

Figure 3: ANOVA Test for Duration.

There was statistically significant difference between groups as determined by anova f (3,268)=182.97, p=0.000. A tukey post hoc test revealed that the time to complete the study was statistically significant higher in group 4 (Table 6). There was no statistical difference between the other groups.

Group		Mean Difference	Sd error	Sig.	95% CI	
					Lower Limit	Upper Limit
1	2	58.85	5.89	0	72.1	41.62
	3	37.04	5.97	0	52.76	21.85
	4	117.1	5.95	0	132.5	101.7
2	1	58.57	5.89	0	41.62	72.1
	3	19.55	5.87	0.005	4.37	34.73
	4	60.24	5.85	0	75.36	45.12
3	1	37.3	5.97	0	21.85	52.76
	2	19.55	5.87	0	34.73	4.37
	4	79.79	5.85	0.005	95.14	64.45
4	1	117.1	5.95	0	101.7	132.5
	2	60.24	5.85	0	45.12	75.36
	3	79.79	5.93	0	64.45	95.14

Table 6: Multiple Comparison.

Discussion

Local anaesthtics form the backbone of pain control techniques in dentistry [9,10]. LA's are the safest and the most effective drugs in medicine for the prevention and management of pain. LA 's are the only drugs that prevent the nociceptive impulse from reaching the patients brain [11] with the introduction of the first amide LA lidocaine HCL in 1948 providing profound anaesthesia of long duation became almost a certainity [12,13] other amides introduced since 1948 include mepivacaine HCL, prilocaine HCL, bupivacaine HCL, etidocaine HCL and articaine HCL. Onset of pulpal anaesthesia commonly occurs within 5-10 minutes, persisting for approximately 60 minutes for articaine HCL,

lidocaine HCL and mepicaine HCl formulations containing vasopressor [14,15]. Local anaesthetics work, if deposited in close proximity to the nerve, they will block the nerve conduction.

However LA suffer a number of drawbacks [16-18];

- containing a vasopressor - sting on injection
- they are associated with a degree of post injection tissue injury
- LA have relatively slow onset
- La do not work as reliably in the presence of infection and inflammation

All these drawbacks can be addressed by anaesthetic buffering which;

- Eliminates the sting
- Reduces tissue injury
- Reduces latency
- Introduces the independent anaesthetic effect of carbon di oxide

Introduces the catalytic effect of carbon di oxide
Chemistry and anaesthetic latency:
To achieve pulpal anaesthesia two things must happen:

- The practitioner must deposit LA in close proximity to the nerve
- LA must cross the nerve membrane to block the sodium channels at present the first requirement is met through the injection technique. However without modification the anaesthetic ability to cross the nerve membrane is dependant on biochemical processes that are out of practitioners control. Thus with alkalinisation there is an alteration of biochemical process, thereby enhances the anaesthetic efficacy [19-21].

Sodium bicarbonate is a systemic alkalinising agent. It increases the plasma bicarbonate concentration, buffers excess hydrogen ions, and raises the pH of the blood, thereby reversing clinical signs of acidosis [4]. We used sodium bicarbonate to increase the pH of the local anaesthetic solution to a more physiological pH [22].

Importance of pH of the Local Anaesthetic Solution

Commercially available 2% lignocaine with 1:80,000 adrenaline solutions have a low pH (3.3). Although reducing the pH extends the shelf life of the solution to around 36 months, and prevents the early oxidation of adrenaline, the solution is more likely to produce a burning sensation on injection and a slower onset of anaesthesia [5].

Increasing the pH of the local anaesthetic solution speeds the onset of its action [5], increases its effectiveness, and makes the injection more comfortable. Alkalinising or increasing the pH of the solution can be achieved by adding sodium bicarbonate.

This increases the free base form of the lignocaine molecule and alkalinises the solution, thereby reducing the pain during injection.

We added 7.5 % sodium bicarbonate to local anaesthetic solution in a dilution of 1/10 [6]. This reduced the pH from 3.05 to 7.38,7.4 to 7.8 which caused the availability of the lipophilic uncharged lidocaine molecules (RN), also called the base, to be more available for diffusion into the membrane of the nerve as the solution was close to the physiological tissue pH of 7.4. When sodium bicarbonate is added it is also available in the tissues as bicarbonate ion, which alkalinises the extracellular pH [23-26]. When extracellular pH is increased by the addition of bicarbonate, the decreased intracellular pH (through diffusion of carbon dioxide produced from the reaction of hydrogen and hydrogen carbonate in extracellular fluid) It also play a part in increasing the effect of the local anaesthetic block through protonation of intracellular free-base local anaesthetic ("ion trapping") and increasing the concentration gradient for the free-base local anaesthetic across the plasma membrane [8,27].

Onset of Anaesthesia

The mean time of onset of anaesthetic effect for lignocaine is 332.12 seconds articaine 185.92 sec, buffered articaine 339.52 sec, buffered lignocaine 239.66 sec. The latency, duration of anaesthetic effect of an anaesthetic solution depends on a number of factors such as intrinsic properties of the drug substance used and anesthetic technique employed [28-30]. In this study all the patients were administered inferior alveolar nerve block with the classical technique using landmark based technique described by Malamed [31].

Other factors also affect the onset and duration of LA including the affinity of local anaesthetic to the lipid and protein components within the nerve membrane, the intrinsic vasodilating activity of local anaesthetic, the presence or absence of a vasoconstrictor in the solution and the vascularity of the injection site [32-35]. With alkalinisation the free base form of the local anaesthetic agent is more lipid-soluble, and so diffuses quickly into the membrane of the nerve [36]. The cytoplasm was acidified by the membrane-permeating carbon dioxide leading to the intracellular "trapping" of the cationic form of the local anaesthetic agent. Increasing the extracellular pH with a constant extracellular concentration of local anaesthetic results in a greater intracellular concentration of local anaesthetic and more complete inhibition of sodium currents, whether or not the intracellular carbon dioxide

concentration or pH changes [37]. When extracellular pH is increased by the addition of bicarbonate, decreased intracellular pH through diffusion of carbon dioxide may also have a role in increasing the local anaesthetic block. Sodium bicarbonate ions also nonspecifically reduce the margin of safety for nerve conduction, and may have a direct action on the binding of the local anaesthetic to the sodium channel [26,27,38].

Duration of Anaesthesia

The mean time of duration of anaesthetic effect for lignocaine is 158.64 seconds articaine 215.49 sec, buffered articaine 195.94 sec, buffered lignocaine 275.74 sec according to anova test.

Duration of anesthetic effect of an anesthetic solution is proportional to its degree of protein binding [39,40]. Articaine presents one of the greatest protein binding percentages of all amide local anesthetics, comparable only to ultra-long action substances such as bupivacaine, ropivacaine and ethidocaine. Mean duration of anesthetic effect for 4%articaine was 215.49 minutes and mean duration of anesthetic effect for 2% lignocaine was 158.64 minutes, the buffered 4% articaine is 195.94 and for buffered 2% lignocaine was 275.74. Increased duration of anesthetic effect gives comfort to the patient postoperatively. Latency and duration of anesthetic effect for buffered lignocaine was both clinically and statistically significant when compare to the other three groups using tukey post hoc test.

Conclusion

This study compares the anesthetic efficacy of 4% articaine, 2% lignocaine, 4% buffered articaine and 2% buffered articaine with epinephrine. Onset, duration of anesthetic effect were compared. We conclude that 4% articaine has faster onset when compared to the other three groups. Buffered lignocaine had significantly longer duration when compared to the other groups. This can be explained based on its different chemical structure, liposolubility, increased protein binding ability, diffusion in soft tissue and increased pulpal anesthesia.

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