RESEARCH PAPER

Effects of 2% Lidocaine with Epinephrine on Hemodynamic Parameters During Dental Extractions: A Prospective Clinical Study

Running Title: *Hemodynamic Effects of Dental Lidocaine-Epinephrine*

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Background: Dental extraction intentionally need local anesthesia in order to provide the patients with better comfort, but inadequate pain control can still occur. Lidocaine with epinephrine is widely used to prolong anesthetic action and reduce bleeding; however, epinephrine may cause hemodynamic changes. This study evaluated the effects of 2% lidocaine with epinephrine on blood pressure and pulse rate in non-hypertensive patients undergoing maxillary and mandibular dental extractions.

Materials and Methods A prospective clinical study was conducted on 100 non-hypertensive patients undergoing dental extraction, including 46 males and 54 females. The participants that divided into two equal groups. Group I comprised patients undergoing maxillary tooth extraction, while Group II included patients undergoing mandibular tooth extraction. Each of these groups were then divided into two equal subgroups: 25 cases required one carpule of local anesthesia, and the remaining 25 required two carpules of local anesthesia for dental extraction. Blood pressure and pulse rate were recorded before injection and at 5 and 10 minutes after administration of local anesthesia. Statistical analysis was performed to compare hemodynamic changes between groups.

Results: Mild transient hemodynamic changes were observed after administration of 2% lidocaine with epinephrine. Increases in systolic blood pressure and pulse rate were more frequent in maxillary than mandibular extractions. At 5 minutes, systolic blood pressure increased in 64% of maxillary and 54% of mandibular cases, while pulse rate increased in 74% and 64% of cases, respectively. Diastolic blood pressure remained relatively stable, particularly in the mandibular group. Although descriptive increases were more frequent in maxillary extractions, no statistically significant differences were observed between groups. Furthermore, no statistically significant differences were found between patients receiving one or two carpules at either evaluation interval.

Conclusion: Administration of 2% lidocaine with epinephrine during dental extraction produced mild, temporary, and clinically insignificant hemodynamic changes in non-hypertensive patients, supporting its safe routine use in dental practice**.**

Keywords: Lidocaine, Epinephrine, Dental extraction, Blood pressure, Pulse rate, Non-hypertensive patient.

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1. Introduction

An important component of daily dental practice is local anesthesia, which represents a crucial and more frequently used drug in dentistry. This is indicated with utmost consistency in restorative dentistry, root canal procedures, extraction and a variety of both surgical & non-surgical procedures in managing painful conditions for improved pain management and patient comfort. Over 300 million local anesthetic cartridges are used each year by dentists in the United States alone [1]. Lidocaine is the most frequently employed local anesthetic agent in dentistry because of its rapid onset, moderate duration of action and acceptable safety profile among currently available dental anesthetics [1,2]. Lidocaine is predominantly metabolised by microsomal oxidative enzymes in the liver and then excreted via the kidneys, with less 10% of drug excreted unchanged [1]. To increase efficacy and the duration of action, local anesthetics are often mixed with vasoconstrictors such as Epinephrine. The advantages of the inclusion of epinephrine are; decrease local blood flow, delay in systemic absorption of local anesthetic agent, prolongation of action duration and reduce bleeding during surgical procedures [3,4]. Although its relative advantages, epinephrine can stimulate both α- and β-adrenergic receptors resulting in transient elevations of blood pressure or heart rate. These cardiovascular responses are particularly relevant in patients with hypertension or cardiovascular disease and warrant appropriate clinical consideration [5].

Local anesthetics are best known to be safe when administered in therapeutic doses, nevertheless no pharmacological drug is entirely free of adverse effects. The degree of systemic absorption, and therefore the cardiovascular effect, is probably influenced by several factors such as the dose of the anesthetic, vascularity of injection site, route of administration and the rate at which local anesthetics are delivered [6]. A key clinical consideration is patient comfort during local anesthetic injection. Needle size, injection technique and speed of anesthetic delivery may play a role in having some effect on the anxiety and discomfort experienced by the patient which indirectly influence cardiovascular responses during dental treatment [6]. Deliberate and anesthetic. In each group, 25 patients were given one cartridge (carpule) of local anesthesia while the other 25 patients received two cartridges during extraction. All the patients were treated at the Department of Oral Surgery, College of Dentistry, in the Erbil City for a period extended from August 2025 until February 2026. Blood pressure and heart was the assessed prior to inject local anesthetic and also at 5 and 10 minutes after injecting it.

2.2. Sample Size

G*Power version 3.1.9.7 was used to calculate the sample size of this prospective clinical study [18]. Using a moderate effect size (Cohen's d = 0.5), significance level (α) of 0.05, and 80% statistical power, the minimum sample size necessary to detect clinically meaningful differences in systolic blood pressure, diastolic blood pressure, and pulse rate following administration of 2% lidocaine with epinephrine during dental extraction procedures was determined to be at least 64 participants. The target sample size was increased to 100 participants in order to improve the dependence of subgroup analyses and additional missing or incomplete data. Of the 118 patients screened for eligibility, 100 met inclusion/exclusion criteria and were enrolled in study (18 were excluded). Thus, a total of 100 participants were included in the final analysis.

2.3. Inclusion/exclusion

This study included patients between 18 and 60 years of age, both males and females. Only individuals requiring simple non-surgical dental extraction of maxillary or mandibular teeth were included. Additionally, participants were required to have normal baseline blood pressure readings with no previous diagnosis of hypertension. Patients with hypertension, pregnant or lactating women, and individuals with a known allergy to lidocaine were excluded from the study. Furthermore, patients requiring multiple dental extractions in both upper and lower arches during the same visit, as well as procedures lasting more than 20 minutes, were also excluded.

2.4. Materials, Instruments, and Equipment

The following materials and equipment were utilized throughout the study: dental syringes (Aesculap, Germany), disposable 27-gauge dental needles (32 mm length), straight elevators and upper and lower extraction forceps made of dental stainless steel (ASA), and sterilized gauze (ChannelMed, China). They were administered with 2% lidocaine with adrenaline 1:100,000 (Madri, Spain; Normon) as a local anesthetic. The anesthetic solution consisted of 20 mg/ml lidocaine as active anesthetic, adrenaline as vasoconstrictor, methyl paraben as preservative; sodium metabisulfite was acting as antioxidant agent and sterile distilled water. An injection needle commercial metal dental syringe for anesthesia delivery was placed. In addition, the blood pressure was assessed by a digital sphygmomanometer. The device included an inflatable cuff, pressure sensor, control unit and digital display which allowed for simple operation while reducing the potential for careful application has been shown to decrease cardiovascular strain and result in improved patient tolerance [7,8]. Differences in the maxilla, mandible and possible anatomical effects involving systemic effects of local anesthesia might also be other determining factors. This is why infiltration anesthesia in most maxillary procedures are very effective since the cortical bone present is thinner and more porous allowing for less resistance to diffusion of the anesthetic solution into cancellous bone [9]. In contrast, the mandible has thicker and denser cortical plates that will frequently need inferior alveolar nerve block techniques and larger required volumes of anesthetic to adequately provide a state of anesthesia [2]. Similarly, mandibular anesthesia is regarded as more unpredictable due to variability in the position of the mandibular foramen and nerve path anatomy [10]. Knowledge of these anatomical and physiological dissimilarities enables the choice of the safest anesthetic modality, appropriate dose and injection method to reduce the potential cardiovascular repercussions [11].

The Assessment of the hemodynamic changes in response to local anesthesia administration in healthy adult population possibly can give useful references data on physiological cardiovascular functional behavior during clinical dental procedures [12]. Nevertheless, only few comparative prospective studies have been conducted to compare the impact of maxillary and mandibular dental extractions on blood pressure and pulse rate after administration of 2% lidocaine with epinephrine in normotensive patients. Cardiovascular fluctuations that are relatively mild may have clinical significance in some population who could be susceptible. Thus, it appears that the association of injection site to hemodynamic response may be involved in producing a safer and more effective dental anesthetic practice. Hence, this present study aimed to answer the following research question: Does administration of 2% lidocaine with epinephrine cause an important change in blood pressure or pulse rate in non-hypertensive patients undergoing dental extractions? Therefore, this prospective study has been undertaken to evaluate the influence of 2% lidocaine with epinephrine on blood pressure and pulse rate in non-hypertensive patients undergoing maxillary and mandibular dental extractions.

2. Methods

2.1. Study Design, Setting, Period, and Sampling

In this prospective clinical study, the effects of 2% lidocaine with epinephrine on blood pressure and heart rate in healthy patients undergoing dental extraction procedures were evaluated. In this descriptive study, 100 patients were included and randomly assigned between the two main groups as per site of extraction through a convenience sampling technique. Group I had 50 patients which included maxillary tooth extraction and Group II consists of 50 patients that required mandibular tooth extraction. Each major group was identified according to the volume of locals: two equal subgroups, patients after injection of 25 mL and those after 50 mL local pressure, diastolic blood pressure, and pulse rate were recorded before anesthetic administration using a calibrated automated electronic sphygmomanometer after a period of rest in the dental chair. Follow-up measurements were obtained at predetermined intervals after injection. All extractions were performed by qualified clinicians using standardized atraumatic non-surgical techniques to minimize tissue manipulation and procedural stress in order to reduce potential effect on cardiovascular response during the procedure.

2.6 Monitoring of Blood Pressure and Pulse Rate

Hemodynamic parameters, including systolic blood pressure, diastolic blood pressure, and pulse rate, were measured at three standardized time points throughout the procedure: immediately before administration of the local anesthetic (baseline), five minutes and ten minutes after anesthetic injection. To standardize measurements and reduce measurement error, all measurements utilized the same automated electronic sphygmomanometer calibrated beforehand. In order to ensure a reproducible and accurate study, all measurements were done under standardized conditions, patients remained seated comfortably in the dental chair with minimal body movements throughout the study time period with consistent cuff placement. Following a sufficient stabilization period to limit the impact of anxiety or exercise on cardiovascular measures, participants relaxed during baseline assessment. When unusual or variable baseline readings were detected, measurements were repeated after a brief rest interval to confirm precision before carrying out the extraction process.

2.7 Postoperative Management

Sterile gauze placed post extraction, patient was advised to bite lightly on the gauze for approximate 30 min with little bleeding in the postoperative period. In this context, all patients were provided with postoperative care instructions at discharge from the hospital including avoidance of hot food/breakfast and drinks, vigorous rinsing, smoking and physical activity within first 24 h after tooth extraction. Patients were given instructions to perform proper oral hygiene without causing trauma to the extraction site. Postoperative pain control with paracetamol (acetaminophen) 1000 mg orally four times daily when required. Amoxiclav orally at a dose of 1000 mg twice daily was given in the event of clinical signs of infection or an increased risk of postoperative infection [13]. Along with mouth wash of 0.2% chlorhexidine gluconate three times a day for seven days the following respective. Routine oral surgery protocols experienced in the Department of Oral Surgery for provision of all medications and postoperative recommendations.

2.8. Measures

Demographic and clinical variables were extracted using a structured extraction checklist. Demographic data (patient age and sex) Hemodynamic parameters included systolic and diastolic blood pressure and heart rate as measured at three time points before the observer-associated errors that is found in manual blood pressure devices.

2.5. Preoperative Patient Preparation

2.5.1 Medical and Dental History

Before extraction, each volunteer had a medical and dental history taken to ensure patient safety as well as inclusion eligibility into the study. A detailed history of systemic disorders, nature of prior hospitalizations, treatment(s) at the time and any previous smoking or ill health or allergies was recorded. We placed particular emphasis on the cardiovascular history: systemic diseases such as arterial hypertension and other diseases that may alter the hemodynamic response to local anesthetics. In addition to these variables, information of history of previous dental procedures (direct exposure to the local anesthetic agent) and any physiological reactions or complications experienced were also recorded.

2.5.2 Clinical and Radiographic Examination

All participants were subjected to thorough clinical and radiographic examinations before dental extraction. Clinical Assessment: The clinical assessment consisted of both extraoral and intraoral examinations and was carried out by a qualified team. General examination was performed with respect to facial symmetry, swelling, lymph node involvement and mouth opening. Intraoral assessment of the tooth scheduled for removal and surrounding soft tissue, periodontal condition carious lesions, teeth mobilization and infection/inflammation present. Oral hygiene status was also evaluated in order to ensure proper treatment planning and attempt to limit the amount of intraoperative and postoperative complications.

Radiographic evaluation was done to assess root/morphology (morphology, number of roots, root curvature), root resorption (indicate possible damage to surrounding bone and proximity to other important anatomical structures ankylosis hypercementosis. Both the radiographs for concurrent pathological lesions or findings to be influenced extraction. Study data were routinely based on periapical radiographs and panoramic radiography (orthopantomograms [OPGs]) at the time of the study for diagnostic support and surgical planning.

2.5.3 Anesthetic Technique and Extraction Procedure

The participants were randomized equally into 2 groups based on dental extraction site. Group 1 included patients having teeth in maxilla extracted, and anesthesia was given with buccal and palatal infiltration methods. Group II included patients requiring mandibular tooth extraction, for whom inferior alveolar nerve block combined with long buccal nerve block anesthesia was used. All patients received 2% lidocaine hydrochloride with epinephrine (1:100,000) supplied in 1.8 mL dental cartridges. Local anesthetic injections were administered under standardized clinical conditions using conventional aspiration techniques to minimize the risk of intravascular injection. The number of cartridges used was determined according to the clinical requirements of each extraction procedure. Baseline systolic blood local anesthesia injection, 5 minutes after delivery of anesthetic, and then again at 10 minutes post administration. The clinical variables included number of anesthetic cartridges employed, extracted tooth name and location (mandibular/maxillary) as well as anesthesia technique type: infiltration anesthesia or inferior alveolar nerve block. Cardiovascular effects of 2% lidocaine with epinephrine for dental extraction procedures were evaluated using these measurements.

2.9. Ethical Approval and Inform Consent

The study was approved by the Institutional Research Ethics Board (IREB) and in accordance with the Declaration of Helsinki. This study was approved by the College of Dentistry, Hawler Medical University Ethics Committee. Written informed consent was obtained from all subjects after full explanation of the study, methods and risks to each subject prior to participation in this study. Written informed consent was obtained from all participants and no private information was disclosed during the course of the study.

2.10. Statistical Analysis

The data were entered and analyzed by using the Statistical Package for the Social Sciences (SPSS) version 31. Participant characteristics and Hemodynamic parameters, Descriptive statistics with means and standard deviations were calculated for participant characteristics and hemodynamic parameters. Independent-samples t-tests were used to compare mean hemodynamic measurements between the maxillary and mandibular extraction groups. Changes in systolic blood pressure, diastolic blood pressure and pulse rate were evaluated over time using repeated-measures analysis of variance (ANOVA), followed by Bonferroni-adjusted post hoc comparisons if indicated. Partial eta squared (η^2) was used to report effect sizes, which provide an index of the magnitude of effects observed. Statistical significance was assumed at a p-value of ≤ 0.05

3. Results

3.1. Socio-Demographic Characteristics of the Study Participants

The socio-demographic characteristics of the study participants revealed that female represented a greater percentage of our sample (54%) than male (46%). In terms of age distribution, the largest group was participants aged 18–29 (30%), followed by those aged 40–49 (25%), ≥50 years (23%) and 30-39 years (22%). The participants' mean age was 39.12 ± 12.30 years demonstrating a broad range of ages in the study population. For the extraction site equal (50%) maxillary and (0/50)% mandibular extractions were performed. The same occurred with the amount of carpules injected, where half of patients were treated with one carpule and half with two. Detailed demographics variables are presented in Table 1.

Table 1. Socio-demographic characteristics of the study participants (n = 100)

Variables		**Frequency**	**Percentage**
Sex	Male	46	46.0
	Female	54	54.0
Age	18-29	30	30
	30-39	22	22
	40-49	25	25
	50 and above	23	23
	Mean (39.12) Std. Deviation (12.30)		
Extraction site	Maxilla (Upper)	50	50
	Mandible (Lower)	50	50
Number of carpules	One carpule	50	50
	Two carpules	50	50
Total		**100**	**100.0**

Note: Values are presented as frequency and percentage unless otherwise indicated. SD = Standard deviation.

3.2. Baseline and Post-Injection Hemodynamic Parameters

Table 2 summarizes the mean systolic blood pressure, diastolic blood pressure and pulse rate is measured at baseline and consecutively for 5-minutes and 10-minutes of follow-up measurements after receipt of 2% lidocaine with epinephrine during dental extraction procedures. In both the maxillary and mandibular groups, systolic blood pressure significantly increased at 5 minutes after injection but decreased modestly at 10 minutes (though still remaining above baseline values). The increase was comparable more prominently noted with mean systolic blood pressure 116.80 ± 6.21 to 124.60 ± 10.54 mmHg in the maxillary group and from114.60 ± 7.88 to 122.40 ± 11.88 mmHg as well in the mandibular group without significant difference (p <0-0). During the observation period, there were only small fluctuations in diastolic blood pressure. The mean at 10 minutes in the maxillary group was nearly unchanged for diastolic blood pressure and significantly decreased within the mandibular group by 5 minutes and then back toward baseline values by 10 minutes. Local anesthesia resulted in a modest increase of 12 b/min pulse rate among both groups. For the maxillary group, heart rate increased from 83.90 ± 10.90 beats/min at baseline to 87.50 ± 10.61 beats/min and to a maximum of 87.92 ± 11.77 beats/min (at minutes5 and10, respectively). As in the maxillary group, an increase was noticed at 5 minutes (82.62 ± 13.68 beats/min to 85.82 ± 12.84 beats/min) but decreased slightly at 10 minutes (84.38 ± 12.16 beats/min). In summary, there were small temporal elevations in systolic blood pressure and pulse rate with lidocaine with epinephrine, whereas diastolic mandibular... Diastolic BP varied little from baseline in both groups; values decreased slightly or near-baseline during follow-up. Pulse rate had small increases at 5 and 10 minutes, the maxillary group were higher than the mandibular group. However, no significant differences between the maxillary and mandibular groups were noted for SBP, DBP or pulse rate at any time point ($p > 0.05$). These findings suggest further that the extraction site had no significant influence on hemodynamic responses to 2% lidocaine with epinephrine.

Table 3. Comparison of Hemodynamic Changes Between Maxillary and Mandibular Extraction Groups

Variable	Time Point	Maxilla Mean Change ± SD	Mandible Mean Change ± SD	t	P-value
SBP	5 min	7.80 ± 9.10	7.80 ± 8.64	0.000	1.000
SBP	10 min	6.20 ± 10.08	5.78 ± 7.57	0.236	0.814
DBP	5 min	0.00 ± 9.04	-1.80 ± 6.91	1.119	0.266
DBP	10 min	0.60 ± 7.67	0.20 ± 6.54	0.281	0.780
PR	5 min	3.60 ± 5.25	3.20 ± 7.48	0.309	0.758
PR	10 min	4.02 ± 6.74	1.76 ± 7.16	1.624	0.108

t-test was used to compare the mean changes between Maxilla and Mandible groups at each time point.

3.4. Clinical Significance and Safety of Hemodynamic Changes

Table 4 illustrates clinical significance and safety assessment of hemodynamic variations associated with administration of 2% lidocaine with epinephrine before dental extractions. The mean maximum SBP increase was 10.59 ± 8.14 mmHg, with 32% of patients exhibiting a change equal to or greater than the clinically important threshold of ≥20mmHg. For diastolic blood pressure (DBP), mean maximum change was 2.10 ± 7.29 mmHg, with >33% of patients demonstrating increases surpassing the threshold of 10 mmHg. The study has shown that Pulse rate observed maximum average increase of 5.18 ± 6.93 bpm and the patients had the increase of 20 bpm more in only five percent. Overall, although transient hemodynamic elevations were observed in some participants, the majority of changes remained within acceptable clinical limits, suggesting that 2% lidocaine with epinephrine was generally well tolerated in healthy non-hypertensive patients undergoing dental extractions.

Table 4. Clinical Significance and Safety Evaluation of Hemodynamic Changes Following Local Anesthetic Administration

blood pressure remained constant. Hemodynamic responses to both maxillary extraction and mandibular extraction were similar between groups, but remained within clinically acceptable limits.

Table 2. Hemodynamic Parameters Before and After Local Anesthetic Administration in the Total Sample

Parameter	Group	Baseline Mean ± SD	5 min Mean ± SD	10 min Mean ± SD
Systolic BP (mmHg)	Maxilla	116.80 ± 6.21	124.60 ± 10.54	123.00 ± 10.93
	Mandible	114.60 ± 7.88	122.40 ± 11.88	120.38 ± 11.93
Total Sample		115.70 ± 7.14	123.50 ± 11.23	121.69 ± 11.46
Diastolic BP (mmHg)	Maxilla	73.60 ± 6.93	73.60 ± 10.45	74.20 ± 9.06
	Mandible	73.40 ± 7.72	71.60 ± 9.76	73.60 ± 8.98
Total Sample		73.50 ± 7.30	72.60 ± 10.11	73.90 ± 8.98
Pulse Rate (beats/min)	Maxilla	83.90 ± 10.90	87.50 ± 10.61	87.92 ± 11.77
	Mandible	82.62 ± 13.68	85.82 ± 12.84	84.38 ± 12.16
Total Sample		83.26 ± 12.32	86.66 ± 11.75	86.15 ± 12.04

Note: Values are presented as mean ± SD. Measurements were obtained at baseline and at 5 and 10 minutes after administration of 2% lidocaine with epinephrine (1:100,000). SBP = systolic blood pressure; DBP = diastolic blood pressure.

3.3. Comparison of Hemodynamic Changes Between Maxillary and Mandibular Extraction Groups

The comparison of hemodynamic changes between maxillary and mandibular extraction groups is shown in Table 3, at 5 & 10 mins after received the injection of 2% lidocaine with epinephrine The two groups had similar trends in blood pressure and pulse rate after receiving the local anesthetic agent. The mean increase in systolic BP at 5 min was the same for both groups (7.80 mmHg) and 10-min changes were also slightly higher in the maxillary group than in compared with baseline measurements. The mean systolic blood pressure increased by 7.80 mmHg at 5 minutes (95% CI: 6.05 to 9.55, $p<0.001$) and by 5.99 mmHg at 10 minutes (95% CI: 4.23 to 7.75, $p<0.001$). However, the difference between 5-minute and 10-minute systolic blood pressure measurements was not statistically significant ($p=0.218$). No significant differences were observed in diastolic blood pressure between baseline, 5-minute, and 10-minute measurements, indicating relative stability of diastolic blood pressure following local anesthetic administration. Pulse rate showed significant increases at both 5 minutes and 10 minutes compared with baseline values. The mean pulse rate increased by 3.40 beats per minute at 5 minutes (95% CI: 2.12 to 4.68, $p<0.001$) and by 2.89 beats per minute at 10 minutes (95% CI: 1.50 to 4.28, $p<0.001$). No statistically significant difference was observed between pulse rate measurements at 5 minutes and 10 minutes ($p=1.000$). For further details, see Table 6.

Table 6. Multiple Comparisons of Hemodynamic Measurements Following Local Anesthetic Administration

Variable	Comparison	Mean difference	95 % CI	p-adjusted
Systolic BP	5 min − baseline	+7.80	6.05 to 9.55	<0.001
Systolic BP	10 min − baseline	+5.99	4.23 to 7.75	<0.001
Systolic BP	10 min − 5 min	−1.81	−3.79 to 0.17	0.218
Diastolic BP	5 min − baseline	−0.90	−2.50 to 0.70	0.799
Diastolic BP	10 min − baseline	+0.40	−1.01 to 1.81	1.000
Diastolic BP	10 min − 5 min	+1.30	−0.10 to 2.70	0.205
Pulse rate	5 min − baseline	+3.40	2.12 to 4.68	<0.001
Pulse rate	10 min − baseline	+2.89	1.50 to 4.28	<0.001
Pulse rate	10 min − 5 min	−0.51	−1.67 to 0.65	1.000

Note: Bonferroni-adjusted post hoc comparisons were performed following repeated-measures ANOVA to identify pairwise differences between baseline, 5-minute, and 10-minute measurements. Mean

Parameter	Mean Maximum Change	Clinically Significant Threshold	Patients Exceeding Threshold n (%)
SBP	10.59 ± 8.14 mmHg	≥ 20 mmHg increase	32 (32%)
DBP	2.10 ± 7.29 mmHg	≥ 10 mmHg increase	33 (33%)
PR	5.18 ± 6.93 bpm	≥ 20 bpm increase	5 (5%)

Mean maximum change represents the highest increase recorded at either 5 minutes or 10 minutes compared with baseline values.

3.5. Repeated-Measures Analysis of Hemodynamic Changes Over Time

Repeated-measures ANOVA demonstrated a statistically significant change over time in systolic blood pressure and pulse rate following administration of 2% lidocaine with epinephrine. Systolic blood pressure showed a significant within-subject effect across baseline, 5-minute, and 10-minute measurements, $F(2,198)=39.03$, $p<0.001$, with a large effect size (partial $\eta^2=0.283$). Pulse rate also demonstrated a significant change over time, $F(2,198)=16.20$, $p<0.001$, with a moderate effect size (partial $\eta^2=0.141$). In contrast, no statistically significant change was observed in diastolic blood pressure across the measured time points, $F(2,198)=1.61$, $p=0.202$, partial $\eta^2=0.016$, indicating a minimal effect of local anesthetic administration on diastolic blood pressure. For further details, see Table 5.

Table 5. Repeated-Measures ANOVA Analysis of Blood Pressure and Pulse Rate

Variable	F-value	df	p-value	Partial η²
Systolic BP	39.03	2, 198	<0.001	0.283
Diastolic BP	1.61	2, 198	0.202	0.016
Pulse rate	16.20	2, 198	<0.001	0.141

Note: Repeated-measures ANOVA was performed to evaluate within-subject changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate across baseline, 5-minute, and 10-minute measurements following administration of 2% lidocaine with epinephrine. Partial η^2 values represent effect sizes. A p-value <0.05 was considered statistically significant.

3.6. Bonferroni Post Hoc Comparisons of Hemodynamic Parameters

Bonferroni-adjusted post hoc comparisons demonstrated significant increases in systolic blood pressure at both 5 minutes and 10 minutes following administration of 2% lidocaine with epinephrine potential life-threatening cardiovascular response to conventional dental dosing in otherwise healthy patients.

Multiple mechanisms may contribute to the observed effects. Some dental anesthetic agents contain high concentrations of epinephrine, which has the potential to elevate plasma catecholamine levels by α- and β-adrenergic stimulation while also leading to modest but significant transient increases in systolic blood pressure and heart rate [4,17]. Concurrently, catecholamine release due to injection discomfort, dental anxiety, nociceptive stimuli and the tooth extraction itself may play a considerable role in the hemodynamic responses being observed [16,19]. Previous studies investigating the effects of dental treatment on cardiovascular responses indicated that the largest fluctuations often occurred during active manipulation or extraction, rather than during anesthetic injection alone [15,18]. The current study did not assess anxiety scales, pain scores or collect biochemical catecholamines in sample at this time point which limited the ability to separate endogenous stress-related responses from direct pharmacologic effects of epinephrine administration.

There are multiple limitations when interpreting the findings of this study. First, as single-center investigation using convenience sampling potentially limits generalizability of findings towards wider populations [20]. Secondly, only patients without hypertension were included in the study, limiting our results to those with either hypertension or cardiovascular disease as well as systemic conditions. Third, cardiovascular responses could only be measured until 10 minutes after administration of the anesthesia itself. Finally, while confidence intervals and effect sizes were reported, further multivariable analyses and longer follow-up periods would have strengthened interpretation. Such limitations do not diminish the study but rather indicate that results should be interpreted as preliminary evidence of comparative hemodynamic behavior across sites and not definitive testing of site-specific hemodynamics.

However, this study is clinically worthwhile despite these limits. The results are directionally consistent with the wider contemporary literature suggesting that conventional dental local anesthetic solutions including epinephrine are commonly well tolerated by healthy adults and in other medically controlled patients, albeit with appropriate monitoring and aspiration techniques [4,15]. Similarly recent evidence from both systematic reviews and clinical studies in hypertensive and other cardiovascular-risk populations has indicated that one to two cartridges of epinephrine-containing dental anesthetic does not result in clinically significant short-term hemodynamic instability. Clinically, these findings lend further support for the careful injection techniques and routinized monitoring of vital signs but not with avoidance of epinephrine-containing local anesthesia in all patients. Future studies should introduce multicenter recruitment strategies, larger and more diverse populations, longer follow-up periods, validated assessment tools for anxiety and differences are presented with 95% confidence intervals (CI). A p-adjusted value <0.05 was considered statistically significant.

4. Discussion

In dental practice, the local anesthetic solution was used for controlling pain during dental extraction. Lidocaine is the most common and safe local anesthetic used in dentistry. This anesthetic is mixed with adrenaline, to decreasing the rate of systemic absorption in the area of injection and diminishing the risk of toxicity of the anesthetic [14].

In this prospective clinical study of non-hypertensive adults undergoing dental extraction, administration of 2% lidocaine with epinephrine was associated with mild, transient changes in hemodynamic parameters. Systolic blood pressure and pulse rate increased shortly after local anesthetic administration, whereas diastolic blood pressure remained comparatively stable, and values generally trended back toward baseline by the later measurement point. Similar transient cardiovascular responses following epinephrine-containing dental local anesthetics have been reported in previous studies, with most changes remaining within clinically acceptable limits in healthy individuals [15,16]. Importantly, although descriptive frequencies suggested somewhat larger increases in some maxillary cases, the inferential analyses presented in the manuscript did not demonstrate statistically significant differences between maxillary and mandibular groups, nor between one- and two carpule subgroups within each site. Comparable findings have been described in recent literature indicating that local anesthetic administration with epinephrine generally produces only minor and short-lived hemodynamic alterations without significant site- or dose-dependent effects in normotensive patients [4,17]. Accordingly, the main interpretation of the findings should be short-term hemodynamic tolerability rather than a confirmed site-specific or dose-specific effect.

This overall pattern is broadly consistent with recent dental-anesthesia literature. Contemporary evidence suggests that administration of epinephrine-containing local anesthetics during routine dental procedures may produce transient increases in blood pressure and heart rate without causing clinically significant cardiovascular instability in healthy individuals [4,15]. Earlier studies have similarly shown that hemodynamic effects induced by lidocaine and epinephrine are minimal, fall well within physiologic ranges and frequently similar to or smaller than cardiovascular responses accompanying procedural stress and anxiety [16]. Likewise, studies assessing adverse hemodynamic effects associated with epinephrine-containing versus drug-free local anesthetic formulations before oral surgical procedures showed no clinically important differences [17,18]. Collectively, these results support the view that the small changes observed in the current sample are more appropriately characterized as representing net effects of exogenous epinephrine, procedural-related stress and anticipatory anxiety than as a

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Author Contributions

Sayran Khorsheed Nareeman and Zainab Aziz Baker contributed to the conceptualization, methodology, data curation, visualization, supervision, writing of the original draft, and reviewing and editing of the manuscript**.**

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pain perception, continuous or more frequent hemodynamic monitoring, and novel statistical methods such as multivariable or mixed-effects modeling which may better define the relative contributions of anesthetic dose, anatomical site, injection technique, and psychological stress responses.

5. Conclusion

This single-center prospective study demonstrated that 2% lidocaine with epinephrine resulted in increases in systolic blood pressure without an increase in diastolic blood pressure and only mild transient elevations of pulse rate among non-hypertensive adults undergoing dental extraction. There were no statistically significant differences between maxillary extractions vs. mandibular extractions or one- and two carpule subgroups in the statistical analyses performed on the data in the manuscripts. The results provide reassurance regarding hemodynamic tolerability of habitual lidocaine epinephrine for short course in routine healthy patients, but further methodologically rigorous clinical trials are required to confirm these findings.

Declarations

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Conflict of Interest Statement

The authors declare no conflict of interest.

Ethical Approval and Informed Consent

Ethical approval for this prospective clinical study was obtained from the Scientific and Ethics Committee of the College of Dentistry, Hawler Medical University, Erbil, Iraq, prior to data collection. The study was conducted in accordance with the principles of the Declaration of Helsinki for research involving human participants. All participants were informed about the purpose and procedures of the study before enrollment. Written informed consent was obtained from each participant prior to participation, and confidentiality of personal information was strictly maintained throughout the study.

Data Availability Statement:

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Consent for publication

Not applicable. No identifying personal or clinical details of participants are included in this manuscript**.**

Permission to reproduce material from other sources

There are no reproduced materials in the current study.

Transparency statement

The lead author **Sayran Khorsheed Nareeman** affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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