

ORIGINAL ARTICLE

Comparison of hemodynamic changes with general or local anesthesia during dental treatment in pediatric patients: A prospective clinical study

Silvia Pérez-García¹  | Johanna Acosta-Ibarra² | Juan-Antonio Ruiz-Roca³ | Cristóbal Añez⁴ | Jordi Gargallo-Albiol^{1,5}

¹Department of Oral and Maxillofacial Surgery, International University of Catalonia, Barcelona, Spain

²Private practice in Barcelona, Barcelona, Spain

³Department of Stomatology, Faculty of Dentistry, University of Murcia, Murcia, Spain

⁴Universitat Rovira i Virgili, Anesthetist, Hospital Universitari de Tarragona Joan XXIII, Tarragona, Spain

⁵Department of Periodontics and Oral Medicine, The University of Michigan, School of Dentistry, Ann Arbor, Michigan, USA

Correspondence

Silvia Pérez-García, Department of Oral and Maxillofacial Surgery, International University of Catalonia, C/ Josep Trueta s/n, Sant Cugat del Vallés, Barcelona, Spain.

Email: sperezga@uic.es

Abstract

Background and aim: Severe hemodynamic fluctuations during dental treatment can trigger highly undesirable physical reactions. A study was made to determine whether the administration of propofol and sevoflurane contributes to the stabilization of hemodynamic parameters during dental treatment in pediatric patients versus the use of local anesthesia alone.

Materials and methods: Forty pediatric patients needing dental treatment were assigned to either general anesthesia with local anesthesia (study group [SG]) or local anesthesia alone (control group [CG]). Two percent sevoflurane in oxygen (100% oxygen, 5 L/min) and continuous propofol infusion (target-controlled infusion [TCI], 2 µg/mL) were used as general anesthesia agents in SG; and 2% lidocaine with 1:80,000 adrenaline was used as local anesthesia in both groups. Heart rate, blood pressure and oxygen saturation were measured before starting dental treatment (baseline) and every 10 min during dental treatment.

Results: Blood pressure ($p < .001$), heart rate ($p = .021$) and oxygen saturation ($p = .007$) decreased substantially after the administration of general anesthesia. The levels of these parameters subsequently remained low and then recovered at the end of the procedure. On the other hand, the oxygen saturation values remained closer to baseline in SG versus CG. In contrast, the hemodynamic parameters experienced lesser fluctuations in CG than in SG.

Conclusions: General anesthesia affords more favorable cardiovascular parameters during the entire dental treatment in comparison to local anesthesia alone (blood pressure and heart rate decrease significantly and oxygen saturation proves more stable and with values closer to baseline), and allows dental treatment to be performed on healthy, lacking cooperative ability children who otherwise could not be treated with local anesthesia alone. No side effects were observed in either group.

KEYWORDS

general anesthesia, hemodynamics, pediatric dentistry

1 | INTRODUCTION

Dental treatment in pediatric patients poses challenging situations. Anxiety and pain can lead to hemodynamic changes affecting blood pressure (BP) and heart rate (HR).^{1,2} Such parameters are also affected by certain individual factors such as age, gender, previous experience with dental treatments, and individual psychological response.² In addition, local anesthetics with vasoconstrictors are also able to induce hemodynamic changes in similar way as anxiety or stress.³ Anxiety in children undergoing dental treatment is characterized by subjective feelings of tension, apprehension, nervousness and worry that may be expressed in behavioral changes.⁴ Severe hemodynamic fluctuations during dental treatment can trigger cardiovascular changes,⁵ and up to 60% of all children undergoing dental treatment may present negative behavioral changes (sleep changes, crying, movement and overall behavior).⁴ Thus, the safe and effective treatment of lacking cooperative ability children remains a major challenge for dentists,⁴ and patients under 3 years of age or with special needs require additional support beyond local anesthesia.^{6,7}

While conscious and moderate sedation is often sufficient for performing the majority of dental treatments in adults, deeper sedation levels or general anesthesia (GA) may occasionally be required in children under 7 years of age and in patients with special needs.^{7–10} Indications for the use of GA can be classified into three main groups: patients with general medical problems; patients with extensive dental needs; and lacking cooperative ability patients.⁸

Recent evidence indicates that parental satisfaction with dental treatment under GA has been continuously increasing over the years and is now accepted more favorably than other active or passive behavioral management techniques.¹¹ General anesthesia seems to be a safe and useful procedure for the dental treatment of children, especially children with special healthcare needs with minimal postoperative complications.¹¹

Therefore, the main objective of the present clinical study was to determine whether the administration of propofol and sevoflurane in general anesthesia contributes to hemodynamic stabilization during dental treatment in healthy children versus the use of local anesthesia alone. As a secondary objective, a hemodynamic parameter assessment was made of whether propofol and sevoflurane

administration represents an advantage over conventional treatment with local anesthesia alone in terms of safety during dental treatment in healthy children.

2 | MATERIALS AND METHODS

The present prospective, non-randomized clinical study was approved by the Ethics Committee of the Faculty of Dentistry of the University of Murcia (Murcia, Spain) (Ref: 1459–2017). Informed consent was obtained from the parents prior to the start of the investigation, explaining to them the procedures, possible discomforts, and risks and benefits involved.

2.1 | Subjects

The preliminary sample size calculation (with 95% confidence interval [95%CI]) yielded a random sample of 17 individuals per group. Therefore, considering possible dropouts, a total of 40 patients were enrolled in the study (20 per group), selected from two private hospitals during a 1-year period (from September 2019 to September 2020), according to the inclusion and exclusion criteria. The inclusion criteria were: (a) patients between 2 and 16 years of age; (b) ASA score I (a normal healthy patient)¹²; (c) patients without neurodivergent conditions associated; (d) need for dental treatment (surgical, restorative or root canal treatments); (e) dental procedures lasting over 20 min (counting from local anesthesia infiltration) and less than 2 h; and (f) administration of 1–4 carpules of 2% lidocaine with 1:80,000 adrenaline as local anesthesia. The exclusion criteria were: (a) ASA score II (a patient with mild systemic disease)¹², III (a patient with severe systemic disease)¹² or IV (a patient with severe systemic disease representing a constant threat to life)¹²; (b) patients with neurodivergent conditions associated; (c) need for sedation (oral or intravenous); (d) dental procedures lasting less than 20 min or longer than 2 h; and (e) administration of less than one or more than four carpules of local anesthesia.

The study sample was divided into two groups: (1) general anesthesia group (study group [SG]), involving 20 patients undergoing dental treatment under general anesthesia with local anesthesia infiltration (this group was previously included in another investigation as a control

group)¹³; and (2) local anesthesia group (control group [CG]): 20 patients undergoing dental treatment with only local anesthesia infiltration.

Patients with needs of dental treatment were recruited and distributed into the study groups according to the inclusion criteria described and, secondly, to the requirement of general anesthesia approach.

All the patients who visited the pediatric dentist at the center were included. All these patients could potentially be referred for general anesthesia for dental treatment and for this reason 2 years was set as the lower limit, since very exceptionally the specialist visits younger patients. Although they might seem pre-cooperative, those patients were lacking cooperative ability children who were not allowed to undergo the treatment using the different management techniques. They suffered severe anxiety, and dental procedures could not be started despite the psychological approaches used. Additionally, some patients had undergone previous attempts of treatment in a conventional setting that had proven unsuccessful. Generally, they made a first visit, as a first contact with the patient (a measure of attempting acclimatization and introducing them to the sights, sounds and smells of the dental environment) and in the second appointment the treatment was attempted. In the event that it could not be carried out with the different behavior modification techniques (two attempts were made, in two different appointments), they were referred to general anesthesia after the third visit, whose waiting time was 2–3 weeks.

General anesthesia was performed by a single anesthesiologist and the corresponding dental treatment was performed by a single pediatric dentist.

2.2 | Study group management

The patients received no anxiolytic premedication the day before surgery. There was a single anesthesiologist for all the treatments. Prior to the administration of any other drugs, baseline vital signs were continuously monitored and recorded (Datex-Ohmeda type F-FM Monitor; Instrumentarium Corp., Helsinki, Finland) by the anesthesiologist. A pediatric blood pressure cuff was placed on the right arm; a pulse-oximetry probe was attached to the index finger of the left hand for the monitoring of oxygen saturation (SpO₂); and three electrodes for continuous electrocardiogram (ECG) recording were placed. In all cases, bispectral index (BIS) monitoring was performed using a Covidien BIS Complete Monitoring System® (Covidien Inc., Mansfield, MA), employing commercially available pediatric BIS sensor strips. The pediatric sensor was placed on the patient forehead and temporal region above the zygomatic arch using self-adhesive. Then, all the

monitoring parameters were continuously displayed and recorded during the entire dental treatment procedure.

Two percent sevoflurane in oxygen was administered by the anesthesiologist on a continuous basis (Mapleson ventilation system, 100% oxygen, 5 L/min). When the BIS values were between 60 and 70, a venous access was prepared on the back of the right hand using a 22G catheter, with the start of continuous propofol infusion (Target-Controlled Infusion, TCI®; Alaris PK Care Fusion, UK), to obtain a targeting effect compartment concentration of 2 µg/mL in 2 min. At the same time, we started to decrease the inhaled sevoflurane concentration to 1%.

A flexometallic laryngeal mask Proseal® airway (LMA) (Teleflex Medical Europe, Ltd.) especially designed to isolate the airway from the digestive tract and prevent pulmonary aspiration, of the required number according to the weight of the patient, was inserted and fixed on the side opposite to the mouth-opener for continuous oxygen administration (2 L/min), under spontaneous breathing conditions at all times.

In those cases where treatment was expected to last long, dexamethasone 0.2–1 mg was administered as an anti-inflammatory and antiemetic measure.

Once the anesthesiologist indicated that optimum hypnotic state had been achieved and was maintained with propofol 2 µg/mL and 1%–2% sevoflurane, with a BIS value between 40–60, the dentist began the administration of local anesthesia (2% lidocaine with 1:80,000 adrenaline, 1.8 mL carpules). The anesthetic method used was the infiltrative or alveolar nerve block depending on whether the treatment was performed in the maxilla or mandible. The amount of local anesthetic used was recorded. The maximum dose of LA was not exceeded for each patient, calculated on their weight upon admission. The treatment was carried out by a single pediatric dentist with more than 15 years of experience in treating children.

In the event of patient discomfort caused by the treatment stimulus (evidenced by movement, complaint, increased HR and/or BP or increased level of consciousness), the anesthesiologist raised the sevoflurane concentration to 3% for 1–2 min, and incremented propofol to 2.5–3 µg/mL. We also recorded unexpected events, such as the need for ventilation support, arrhythmias, vomiting, a dislodged or obstructed endotracheal tube, disconnection of the intravenous line, edema of the tongue or lips and nasal bleeding are intraoperative complications.

At the end of dental treatment, propofol and sevoflurane were stopped. When the patient presented a BIS of 80–90, the laryngeal mask was removed and spontaneous breathing was maintained with manual help according to the individual wake-up time. Then the patients were moved to the anesthesia recovery room with their parents. All patients were kept under observation for

30–45 min after surgery, with pulse-oximetry and BP monitoring. They were then discharged in accordance with the usual criteria for major ambulatory anesthesia: stable vital signs, the ability to stand, no bleeding, nausea and/or vomiting, and no moderate or severe pain.

Postoperative instructions were provided, and analgesic (dexametoprolfen) and antiemetic (metoclopramide hydrochloride) medication was prescribed. Parents were phone called on the same day in the afternoon and on the following day to assess possible complications.

2.3 | Control group management

After seating the patient in the dental chair, a blood pressure cuff was wrapped around the right arm and a pulse-oximetry probe was attached to the index finger of the left hand. The same monitor (Datex-Ohmeda type F-FM Monitor, Instrumentarium Corp., Helsinki, Finland) was used to continuously assess the hemodynamic parameters during the entire dental treatment procedure. Then the dentist began the administration of local anesthesia (2% lidocaine with 1:80,000 adrenaline, 1.8 mL carpules) not exceeding maximum dose, based on weight. Infiltrative or alveolar nerve block technique was used depending on whether the treatment was performed in the maxilla or mandible and the amount of local anesthetic used was recorded. The treatment was carried out by the same pediatric dentist and the monitoring and data collection was also carried out by the same anesthesiologist than in the SG too. He was not involved in the data analysis of the study.

After treatment, instructions to be followed by the patient were explained and, if needed, ibuprofen 400 mg every 8 h was prescribed as analgesia.

2.4 | Data Collection

All the data collected were blinded to the investigator in charge of evaluating the results. A single investigator assessed the level of alertness and recorded the hemodynamic parameters in order to eliminate interobserver variability.

Heart rate, systolic and diastolic blood pressure (SBP and DBP), and SpO₂ were recorded at baseline (on seating the patient in the dental chair), at the start of treatment (after local anesthesia infiltration), and every 10 min until the end of treatment. Final data recording was performed when the dental treatment was completely finished in the CG, and when the patient was in the anesthesia recovery room in the SG. Any unexpected events during the entire treatment time and during the postoperative course in both groups were also recorded.

2.5 | Statistical Analysis

The mean of all measurements over the entire period was defined as the central segment of the intervention period. The Shapiro-Wilks test was used to assess the fit to normal distribution of vital signs within each group. Nonparametric Brunner-Langer models for longitudinal data were applied to determine whether changes in the different vital signs throughout the intervention were similar in both groups (p-value with Bonferroni correction). An ATS-type ANOVA statistic was calculated to evaluate changes throughout the intervention and differences according to the group. The level of significance used was 5% ($\alpha = 0.05$), with a confidence level of 95%. Power analysis was estimated at 99% and 86% for differences over time and between groups, respectively, considering a large effect size to detect $f = 0.4$. The SPSS version 25.0 statistical package (Chicago, IL) was used throughout.

3 | RESULTS

3.1 | Sample description

Forty patients were initially enrolled in the study between September 2019 and September 2020. One patient was excluded due to data recording issues. The final sample distribution was 19 patients undergoing dental treatment under general and local anesthesia (SG), and 20 controls undergoing dental treatment with local anesthesia only (CG). The sex distribution was 7 males and 12 females in SG and 15 males and 5 females in the CG. The mean patient age was 5.2 ± 1.8 years in SG, range 2–8 years and 10.4 ± 3.3 years in CG, range 6–16 years. The allocation of patients to each of the groups resulted in a lower age for patients in the general anesthesia group versus patients in the local anesthesia only group. Thus, since the vital constants could be influenced by the age of the patient, changes in the constants throughout the treatment were assessed to determine whether they were similar in both groups.

All the treatments were performed using the standard techniques, involving restorations, pulp therapies, extractions of temporary and permanent teeth, topical applications of fluoride, ultrasonic scaling, sealants and crowns. In the SG, we performed 71 restorations, 20 pulp therapies, 10 extractions, 24 sealants applications, 11 topical applications of fluoride, 6 ultrasonic scaling and 4 crowns. In the CG the number of restorations was 16, with a single pulp treatment, 7 extractions and two sealants applications. No crowns or ultrasonic scaling were performed in this group (Table 1). Finally, the mean number of local anesthetic carpules used was 0.95 (range 0–1.5)

TABLE 1 Dental treatments performed on patients (CG and SG distribution). (CG: Control group, SG: Study group).

		Group					
		Total		CG		SG	
		N	%	N	%	N	%
Restorations	Total	39	100.0%	20	100.0%	19	100.0%
	0	10	25.6%	6	30.0%	4	21.1%
	1	12	30.8%	12	60.0%	0	.0%
	2	3	7.7%	2	10.0%	1	5.3%
	3	2	5.1%	0	.0%	2	10.5%
	4	4	10.3%	0	.0%	4	21.1%
	5	4	10.3%	0	.0%	4	21.1%
	6	2	5.1%	0	.0%	2	10.5%
	7	1	2.6%	0	.0%	1	5.3%
	8	1	2.6%	0	.0%	1	5.3%
Pulp therapies	Total	39	100.0%	20	100.0%	19	100.0%
	0	30	76.9%	19	95.0%	11	57.9%
	1	6	15.4%	1	5.0%	5	26.3%
	2	1	2.6%	0	.0%	1	5.3%
	3	1	2.6%	0	.0%	1	5.3%
	7	1	2.6%	0	.0%	1	5.3%
Extractions	Total	39	100.0%	20	100.0%	19	100.0%
	0	29	74.4%	15	75.0%	14	73.7%
	1	5	12.8%	3	15.0%	2	10.5%
	2	4	10.3%	2	10.0%	2	10.5%
	4	1	2.6%	0	.0%	1	5.3%
Topical fluor	Total	39	100.0%	20	100.0%	19	100.0%
	No	27	69.2%	19	95.0%	8	42.1%
	Yes	12	30.8%	1	5.0%	11	57.9%
Ultrasonic scaling	Total	39	100.0%	20	100.0%	19	100.0%
	No	33	84.6%	20	100.0%	13	68.4%
	Yes	6	15.4%	0	.0%	6	31.6%
Sealants	Total	39	100.0%	20	100.0%	19	100.0%
	0	30	76.9%	18	90.0%	12	63.2%
	1	4	10.3%	2	10.0%	2	10.5%
	2	2	5.1%	0	.0%	2	10.5%
	4	1	2.6%	0	.0%	1	5.3%
	7	2	5.1%	0	.0%	2	10.5%
Root treatment	Total	39	100.0%	20	100.0%	19	100.0%
	No	36	92.3%	20	100.0%	16	84.2%
	Yes	3	7.7%	0	.0%	3	15.8%
Preformed crowns	Total	39	100.0%	20	100.0%	19	100.0%
	0	37	94.9%	20	100.0%	17	89.5%
	1	1	2.6%	0	.0%	1	5.3%
	3	1	2.6%	0	.0%	1	5.3%

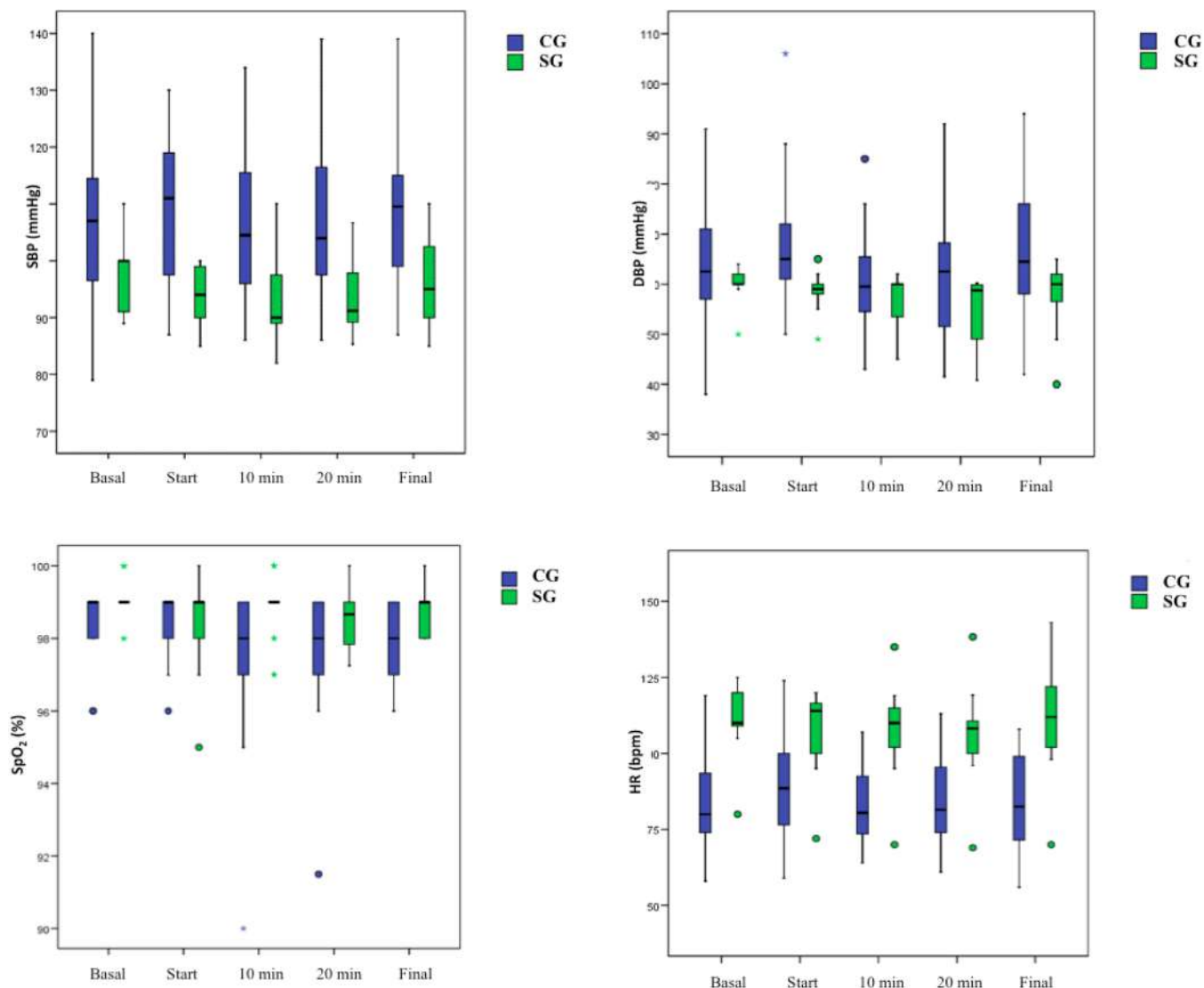


FIGURE 1 Evolution upon the four variables (SBP, DBP, SpO₂, HR) over time according to each study groups (SBP: systolic blood pressure, DBP: diastolic blood pressure, SpO₂, HR: heart rate).

and 2.18 (range 1–4) in the study and control group, respectively.

3.2 | Systolic blood pressure

Systolic blood pressure showed a statistically significant decrease ($p < .001$) in SG. In contrast, in CG the SBP values were characterized by a stable pattern ($p = .106$) (Figure 1). The marked decrease observed in the general anesthesia patients was related to the initial dose of propofol administered ($p = .088$), but not to the dose of sevoflurane: a higher dose of propofol (≥ 200 mg) resulted in a more intense drop in SBP and also a stronger subsequent recovery.

The evolution of SBP in CG was not the same in those under versus over 10 years of age ($p = .033$): the SBP value

tended to rise ($p = .071$) in patients under 10 years of age and proved more stable or even exhibited a downward trend among those ≥ 10 years of age ($p = .197$).

The evolution of the SBP variable over the time it is represented on Figure 2 and Table 2.

3.3 | Diastolic blood pressure

Diastolic blood pressure behaved in the same way as SBP in SG, with more stable values in CG ($p = .106$). General anesthesia caused a more sustained decrease and later recovery of DBP throughout the intervention ($p < .001$) (Figure 3). The changes in DBP were significantly conditioned by the dose of propofol and sevoflurane administered. A lower propofol dose (150 mg) caused DBP to decrease progressively until final recovery

TABLE 2 Evolution upon the four variables (SBP, DBP, SpO₂ and HR) during the intervention by Group: Median and results of the ATS test of the Brunner-Langer model in relation to time and group (*p*-value) (SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SpO₂, HR: Heart rate).

		Basal	Start	10 min	20 min	Final	
SBP	CG	107.0	111.0	104.5	104	109.5	Time <i>p</i> = .033* Group <i>p</i> < .001*** Interaction <i>p</i> = .035*
	SG	100.0	94.0	90.0	91.2	95.0	
DBP	CG	62.5	65.0	59.5	62.5	64.5	
	SG	60.0	59.0	60.0	58.8	60.0	Time <i>p</i> = .0303* Group <i>p</i> < .001*** Interaction <i>p</i> = .035*
SPO ₂	CG	99.0	99.0	98.0	98.0	98.0	Time <i>p</i> = .007** Group <i>p</i> = .012* Interaction <i>p</i> = .079
	SG	99.0	99.0	99.0	98.7	99.0	
HR	CG	88.0	88.5	80.5	81.5	82.5	
	SG	110.0	114.0	110.0	108.3	112.0	Time <i>p</i> = .066Group <i>p</i> < .001*** Interaction <i>p</i> = .052

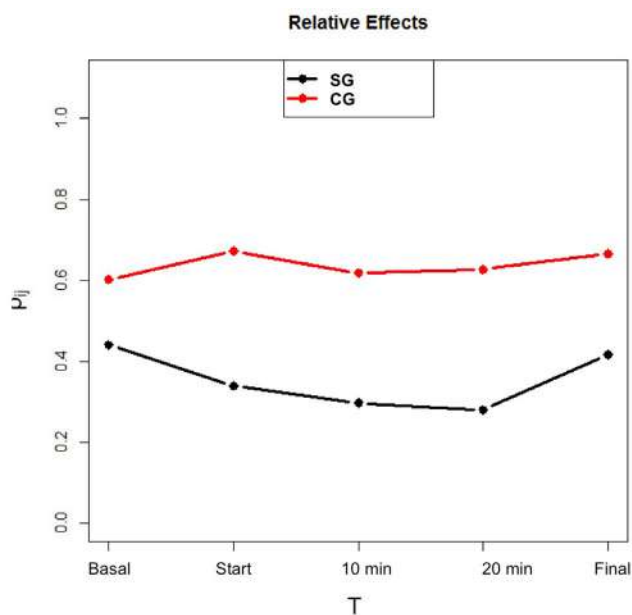


FIGURE 2 Relative effects upon SBP over time (SBP: systolic blood pressure; SG: study group [general anesthesia with local anesthesia]; CG: control group [local anesthesia alone]; P: relative effects; min: minutes; T: time).

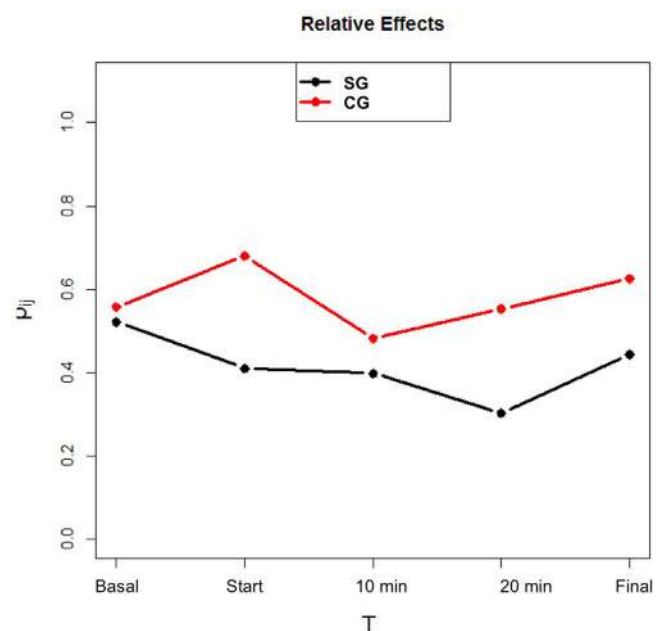


FIGURE 3 Relative effects upon DBP over time (DBP: diastolic blood pressure; SG: study group [general anesthesia with local anesthesia]; CG: control group [local anesthesia alone]; P: relative effects; min: minutes; T: time).

(*p* = .045). The same effect was caused by a higher dose of sevoflurane ($\geq 2\%$), where there was a clearer decrease in the parameter (*p* = .039). The DBP values proved more stable in CG, in line with what was observed with SBP. However, no differences were observed between age levels (*p* = .641).

The evolution of the DBP variable over the time it is represented on Figure 2 and Table 2.

3.4 | Oxygen saturation

The SpO₂ values decreased significantly throughout treatment in both groups (*p* = .007) (Figure 4). The reduction of this parameter was slightly greater at the beginning of treatment in SG (*p* = .01) compared to CG (*p* = .068), though the local anesthesia patients exhibited lower SpO₂ over the treatment period than the general anesthesia patients. In SG, the changes in saturation were significantly related to the dose of propofol administered

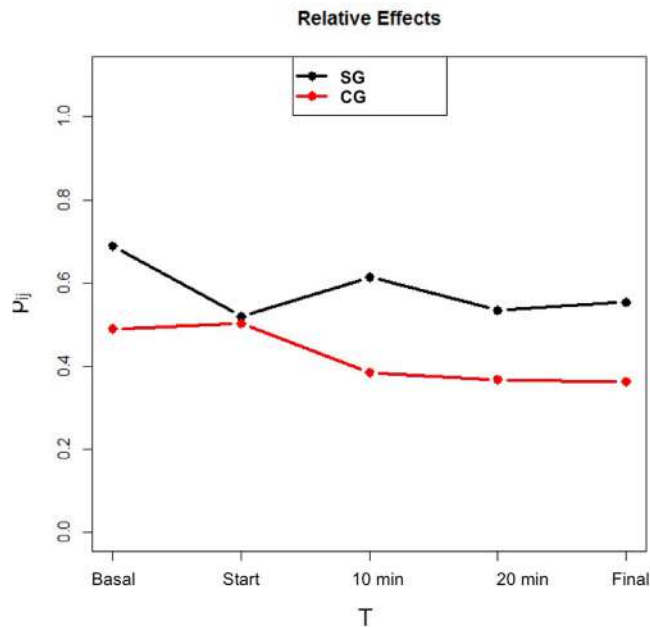


FIGURE 4 Relative effects upon SpO₂ over time (SpO₂: oxygen saturation; SG: study group [general anesthesia with local anesthesia]; CG: control group [local anesthesia alone]; P: relative effects; min: minutes; T: time).

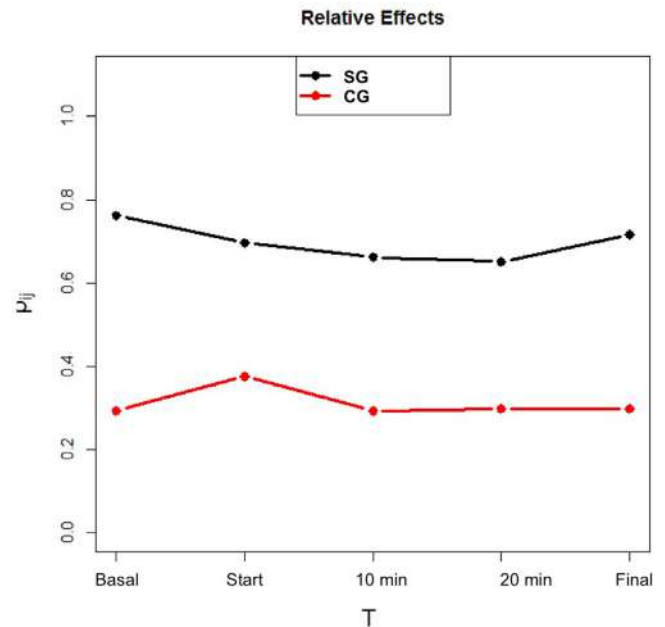


FIGURE 5 Relative effects upon HR over time (HR: heart rate; SG: study group [general anesthesia with local anesthesia]; CG: control group [local anesthesia alone]; P: relative effects; min: minutes; T: time).

($p = .002$):—a higher dose (≥ 200 mg) causing clearer stabilization of SpO₂.

The evolution of the SpO₂ variable over the time it is represented on Figure 2 and Table 2.

3.5 | Heart rate

As with the previous parameters, general anesthesia caused a clearer decrease in HR, although the mean value was lower in the local anesthesia patients than when using general anesthesia, and time course throughout dental treatment proved different in each group: HR value decreased more clearly during treatment in SG ($p = .021$), compared with greater stability in CG ($p = .263$) (Figure 5). In contrast to SBP and DBP, the changes in HR were not dependent upon the of propofol dose administered, but were positively influenced by sevoflurane: a higher dose of sevoflurane ($\geq 2\%$) resulted in a more noticeable drop in HR ($p = .047$).

The evolution of the HR variable over the time it is represented on Figure 2 and Table 2.

3.6 | Other analyses

As we have already mentioned, SBP remained stable in CG. However, the evolution was not the same in those

younger versus older than 10 years ($p = .033$). Among children under 10 years of age, SBP tended to increase ($p = .071$), while among those over 10 years of age, more stability or even a downward trend was observed ($p = .197$).

In the SG, the SBP values changed significantly over time ($p = .002$) but following a similar pattern regardless of patient age ($p = .479$).

The evolution of SpO₂ in SG was conditioned by the age of the patient ($p = .012$). In those patients under 5 years of age were recorded a rapid drop in the parameter at the beginning of the intervention, while in those over that age the drop occurred towards the end of the intervention. In CG, the decrease occurred in a similar way in both age groups.

Diastolic blood pressure, HR, patient gender and the total dose of local anesthetic used had little influence upon the evolution of the vital constants.

Lastly, no side effects such as nausea, vomiting, respiratory depression or tachycardia were observed in any patients in either group. There was only one case of disconnection of the intravenous line and another in which the endotracheal tube was dislodged. In both cases the anesthesiologist quickly resolved the problem, and dental treatment could continue without further incidents.

4 | DISCUSSION

The present prospective study reveals that hemodynamic parameters such as BP, HR and SpO₂ decrease after the administration of general anesthesia in healthy children undergoing dental treatment, in contrast to what was observed in patients treated with local anesthesia alone. Nevertheless, SpO₂ parameter proved to be more stable and with values closer to baseline over the treatment period in the general anesthesia patients. Therefore, although no side effects were observed during and after the procedure, thus reflecting the safety of both anesthetic protocols, general anesthesia resulted in more favorable cardiovascular parameters during the entire dental treatment, and allowed the latter to be performed in healthy, lacking cooperative ability children who otherwise could not be treated with local anesthesia alone.

Most dental procedures can be performed in pediatric patients using non-pharmacological behavioral-based measures, though nitrous oxide inhalation offers good results in children with mild anxiety levels.¹⁴ However, the success rate with conscious sedation is low in patients with severe anxiety, and deep sedation with intravenous agents or general anesthesia may be a better option for dental treatment in such cases.¹⁴

Patients under general anesthesia often require assistance in maintaining a patent airway; positive pressure ventilation may be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function, and cardiovascular function may be impaired.^{15,16} In our study, muscle relaxants were not used, regardless of the drugs used to achieve optimal state of hypnosis (hypnotics [propofol], inhalants [sevoflurane]), and spontaneous ventilation was always maintained, relying on the support of a laryngeal mask if ventilation spontaneous ventilation proved inappropriate.

More often than not, anesthesiologists use a combination of more than one drug to achieve the desired anesthetic state.¹⁷ The coadministration of propofol and sevoflurane has been suggested because of the antiemetic effect of propofol, the myocardial protective effects of sevoflurane, and the possibility of smooth emergence resulting from low administered amounts of each anesthetic.¹⁸ It has been frequently reported that propofol can reduce the incidence of emergence agitation in children undergoing sevoflurane anesthesia.¹⁸ The results of Feng et al.¹⁹ showed that patients undergoing radical gastrectomy with the combination of sevoflurane and propofol had stable respiration and circulation during anesthesia, quick recovery of early consciousness and a low incidence of adverse reactions. The data presented by Sebel et al.¹⁷ showed propofol and sevoflurane to modulate

GABA receptor function and generate the anesthetized state in an additive manner, and with good sedation effects.¹⁸

Our study showed SBP, DBP and HR to decrease significantly throughout dental treatment in general anesthesia patients, and found SpO₂ to be more stable and with better values in patients under general anesthesia due to the fact that the continuous supply of oxygen is maintained with the laryngeal mask airway. This is partially in agreement with the findings of Saravia et al.²⁰ and Patterson et al.,²¹ who reported fluctuations in SBP during treatment under sedation, but without statistical variations between the preoperative and operative readings. Although dental manipulation causes a significant increase in SBP in sedated patients,²¹ our study evidenced a significant decrease in SBP in the general anesthesia group, without changes related to local anesthetic injection or dental manipulation. The absence of changes was probably a consequence of the deep level of anesthesia achieved due to 2% sevoflurane, and the decrease was related to the propofol dose administered—observing a greater drop and greater ultimate recoveries with higher doses of the drug. In line with these observations, Canpolat et al.¹⁴ found mean arterial pressure to always be lower when they administered propofol versus other drugs in pediatric sedation.

Overall, the significant decrease in SBP in the general anesthesia group (SG) contrasted with the more stable pattern observed in local anesthesia group (CG). Although we recorded an increase in SBP after the injection of local anesthetic in CG, it failed to reach statistical significance. This is in line with the results of Sanadhya et al.,²² who found SBP to be highest during local anesthetic injection, followed by during tooth extraction in non-sedated patients. The increment of SBP after the injection has been associated to the combination of the epinephrine concentration contained in the local anesthetic solution,² and the possible association between emotional stress and fear with sympathetic activity (tachycardia) with an increase in the plasma concentrations of adrenaline and norepinephrine, or both.²²

In contrast to our findings, Patterson et al.²¹ and Sanadhya,²² reported a significant increase in DBP related with the injection of anesthesia and/or dental manipulation in sedated and non-sedated patients. In our study, the significant decrease seen in DBP in the general anesthesia group was related to a lower dose of propofol (150 mg) and to a higher dose of sevoflurane ($\geq 2\%$), and was not related at all to anesthesia injection or dental manipulation. Furthermore, our series confirmed the stability of DBP, with no significant differences among the five study timepoints in the local anesthesia patients.

No hypoxia episodes were recorded in our study, but SpO₂ was the only variable that failed to recover at the end of treatment with respect to the baseline value in SG. There was a clear stabilization of SpO₂ when a higher propofol dose was administered, and SpO₂ was also higher in SG throughout the entire period than in CG, indicating the better control of this parameter when using the general anesthesia approach.

Regarding HR, we observed an increase after the injection of local anesthetic in CG, though without reaching statistical significance. These findings are in agreement with those of Sanadhya et al.,²² who found HR to be highest during local anesthetic injection, followed by during tooth extraction in non-sedated patients, and this was moreover associated to anxiety. The association between emotional stress and fear with sympathetic activity,² tachycardia with an increase in the plasma concentrations of adrenaline and norepinephrine, or both mechanisms, could explain these effects.²² In addition, the significant decrease in HR in SG recorded in our study did not depend on the dose of propofol administered but was influenced by the dose of sevoflurane—higher doses of the latter drug resulting in a greater decrease in HR. In contrast, some studies have found that other sedative drugs such as ketamine induce a statistically significant increase in HR.¹⁶

Side effects associated to sedative drugs have been described, such as hypoxia, nausea, vomiting or tachycardia^{7,14,20,23} or allergic reactions to some of the drugs used to perform the general anesthesia.²⁴ Additionally, anesthetic agents are associated with some hazard and risk to overall patient health with some reports of morbidity and mortality.²⁵ In line with the study of Pecci-Lloret et al.,¹¹ we recorded no side effects during our study. In a similar manner, Caputo et al.²⁶ showed mortality in patients with special needs to be minimal and morbidity was limited to minor events. Nevertheless, side effects may occur during these procedures (postextubation croup, wheezing intraoperatively and bradycardia²⁷), and despite the low incidence of adverse outcomes from general anesthesia in the dental office setting, treatment should be safely and efficiently completed with well-trained professionals following established protocols and guidelines.^{11,27}

Another aspect to consider is when a non-cooperative patient undergoes general anesthesia, they require a greater number of dental treatments (many times, the oral pathology they present is extensive due to having delayed the visit to the dentist). Given an equal number of treatments to be carried out on a patient, in collaborating patients it is decided to carry out multiple sessions, these

being shorter in terms of their duration so that the patients do not get tired and maintain their cooperation.

Finally, this study has revealed that general anesthesia reduces cardiovascular parameters such as BP and HR, and maintain the SpO₂ values closer to baseline during the entire dental treatment in children, which may indicate a reduction of the patient stress. The physical and mental stress that patients experience during dental treatment induces hemodynamic changes,^{2,28} increasing the HR and BP, and reducing of the SpO₂. In this context, general anesthesia can modify the hemodynamic parameters in healthy children during dental treatment and, consequently, reduce stress and increase patient satisfaction.¹ Definitely, it could be a good alternative for dental treatment needs in lacking cooperative ability healthy patients, who otherwise could not be treated.²⁹ However, although GA is a safe procedure, negative aspects described by the patient himself and their parents, which include hunger due to fasting, eating disorders, fear or worry, and discomfort from the intravenous cannula,^{30,31} must be not forgotten.

The Brunner-Langer model has clearly shown the difference between the groups ($p < .001$), and despite it does not compare means or medians, it is the most appropriate statistical analysis for a non-parametric approach.^{32,33}

Our study presented some difficulties and limitations. The available literature on the behavior of cardiopulmonary parameters in dentistry and under general anesthesia involving pediatric patients is limited. Additionally, it has been very challenging to recruit a sufficient number of a priori vulnerable subjects and to obtain parental consent to accept treatment under general anesthesia. Nevertheless, recent evidence suggests that parental satisfaction with dental treatment under general anesthesia has increased in recent years and it is now accepted more favorably than other active or passive behavioral management techniques.¹¹ Furthermore, general anesthesia ensures that the child receives effective pain control, and professionals do not need to be concerned about adequate patient cooperation.²⁵ It undoubtedly takes an extra effort on the part of the dental professionals to make the advantages of this treatment modality understood in lacking cooperative ability and very anxious pediatric patients. On the other hand, attempts to unify the study groups in terms of patient age in order to avoid wide differences would allow us to better understand the behavior of the vital constants in both groups. Lastly, and considering the small changes recorded in some of the study parameters, a larger sample size would also be advisable in future investigations.

5 | CONCLUSIONS

General anesthesia seems to afford more favorable cardiovascular parameters during the dental treatment process versus local anesthesia alone in pediatric patients, showing a significant lower systolic and diastolic blood pressure, and heart rate. In addition, it allows dental treatment to be performed on healthy, lacking cooperative ability children who could not be treated with local anesthesia alone.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that they have no financial or personal relationships, with other people or organizations that could inappropriately influence (bias) their work either directly or indirectly, in relation to the products or information listed in the paper.

ETHICS STATEMENT

The study was approved by the Ethics Committee of the Faculty of Dentistry of the University of Murcia (Murcia, Spain) (Ref.: 1459–2017).

ORCID

Silvia Pérez-García  <https://orcid.org/0000-0002-5104-6653>

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