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ORIGINAL RESEARCH

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Postoperative adverse reactions in dental treatment under general anesthesia: a comparative analysis between preschool and school-age children in China

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Abstract

Background: To investigate the incidence of postoperative adverse reactions in children dental treatment under dental general anesthesia (DGA) and to compare the difference in distribution between preschool and school-age children in China. **Methods**: Participants of this study were 130 preschool children and 128 school-age children who underwent DGA from January to September 2024. Data collected included questionnaire-based basic information, postoperative complications and a parental satisfaction survey within three days. Date was analyzed and compared between two group. **Results**: 84.9% of the included children experienced $\geq$1 adverse reactions. The incidence of postoperative adverse reactions was higher in preschool children than that in school-age children (91.4% *vs.* 78.5%, $p < 0.05$). The most common adverse reactions in both groups were pain and negative emotions. The incidence of postoperative pain (75.4%), negative emotions (76.2%), significant occlusal discomfort (23.1%), fever (13.1%) and the average number of treated teeth (15 $\pm$ 3.7), root canal treatments (3.3 $\pm$ 2.2) and pulpotomies (2.0 $\pm$ 1.9) was higher in preschool children than that in school-age children (57.8%, 29.7%, 7.8% , 4.7% and 14 $\pm$ 3.1, 1.9 $\pm$ 1.6 and 1.2 $\pm$ 1.6, respectively) ($p < 0.05$). The probability of drowsiness was higher in school-age children than that in preschool children (22.7% *vs.* 10%, $p < 0.05$). The average number of extractions in preschool children was lower than in school-age children (1.8 $\pm$ 1.9 *vs.* 3.1 $\pm$ 2.7, $p < 0.05$). In addition, the average number of full crown treatments in preschool children was higher than in school-age children, yet without statistically significant difference (5.1 $\pm$ 2.3 *vs.* 3.3 $\pm$ 2.2, $p > 0.05$). **Conclusions**: Children may experience very high probability of postoperative adverse reactions after DGA. Preschool children may develop more adverse reactions than school-age children, necessitating more attention and effective soothing measures for this group of children.

Keywords

Pediatric dentistry; General anesthesia; Adverse reactions; Dental treatment

1. Background

Dental caries is one of the most common oral diseases worldwide, imposing a severe burden on public health and economy, and significantly compromising patients' quality of life [1]. The prevalence of dental caries for deciduous teeth, as estimated by the Fourth National Oral Health Epidemiological Survey in China, are 50.8%, 63.6% and 71.9% in the age groups of 3, 4 and 5 years, respectively. The prevalence of dental caries remains a clear upward trend in Chinese children, severely affecting the oral and overall health of children [2].

Children are a special group that usually cannot cooperate with routine outpatient treatment due to severe dental phobia, severe early childhood caries, low compliance resulting from young age, disabilities, *etc.* They may require treatment under varying degrees of sedation, including mild sedation, moderate sedation, deep sedation or general anesthesia [3].

Dental general anesthesia (DGA) has been increasingly recognized and accepted by medical professionals and patients with social progress and the overall development of dentistry. It allows children to undergo effective, convenient, and efficient dental treatment in a safe and comfortable environment, which may benefit the completion of complex oral disease treatments in one session. It is an efficient approach for restoring children' oral health given that it works to recover chewing function, avoid repeated visits and dental fear, prevent negative dental experiences and enable rapid transition of the oral microecological environment to a balanced state [4].

However, DGA may still induce some postoperative complications compared to routine outpatient treatment. These events, with rare threaten to life safety, can compromise children' postoperative comfort, delay the recovery to normal

daily activities, and decrease the satisfaction of children and their parents. In view of the above, the present study was conducted to analyze the incidence of post-DGA adverse reactions in preschool and school-age children, and compare their distribution among different age groups. Findings in this study may facilitate the implementation of higher-quality dental care services clinically, providing more comfortable and safe medical services for children.

2. Methodology

2.1 Study participants, sampling procedures and sample size estimation

This project was approved by the Ethics Committee of West China Hospital of Stomatology, Sichuan University (Approval No.: WCHSIRB-CT-2023-317). In our study, the estimation of sample size was realized by using the G-Power Sample Size Calculator (version 3.0.10, University of Düsseldorf, Düsseldorf, NRW, Germany) [5], and utilizing statistics of multiple regression with moderate effect size of 0.5 at the level of significance (α = 0.05) and power of 0.8, acknowledging 8 predictors. The estimated sample size was at least 128 subjects for each group. Fig. 1 shows the sampling procedure. Finally, this study enrolled 258 pediatric patients who underwent dental treatment under DGA at the Department of Pediatric Dentistry, West China Hospital of stomatology, Sichuan University from January 2024 to September 2024. Two groups based on age were established, including the preschool group (3–5 years old), and the school-age group (6–14 years old), with 130 patients and 128 patients, respectively.

Children were included if they: (1) aged between 3 to 14 years; (2) suffering from severe caries, with ineffective outcome by other behavior management techniques, and no regular outpatient treatment; and (3) were classified as American Society of Anesthesiologists Physical Status classification of I or II.

Written informed consent in aspects of the anesthesia method, treatment approach and participation in this study was obtained from the parents or legal guardians of the enrolled children. This study excluded those who refused postoperative follow-up, or did not complete the follow-up questionnaire.

2.2 DGA procedure

All children were required to fast for 6–8 h and refrain from drinking water for 2 h before the procedure. Children were

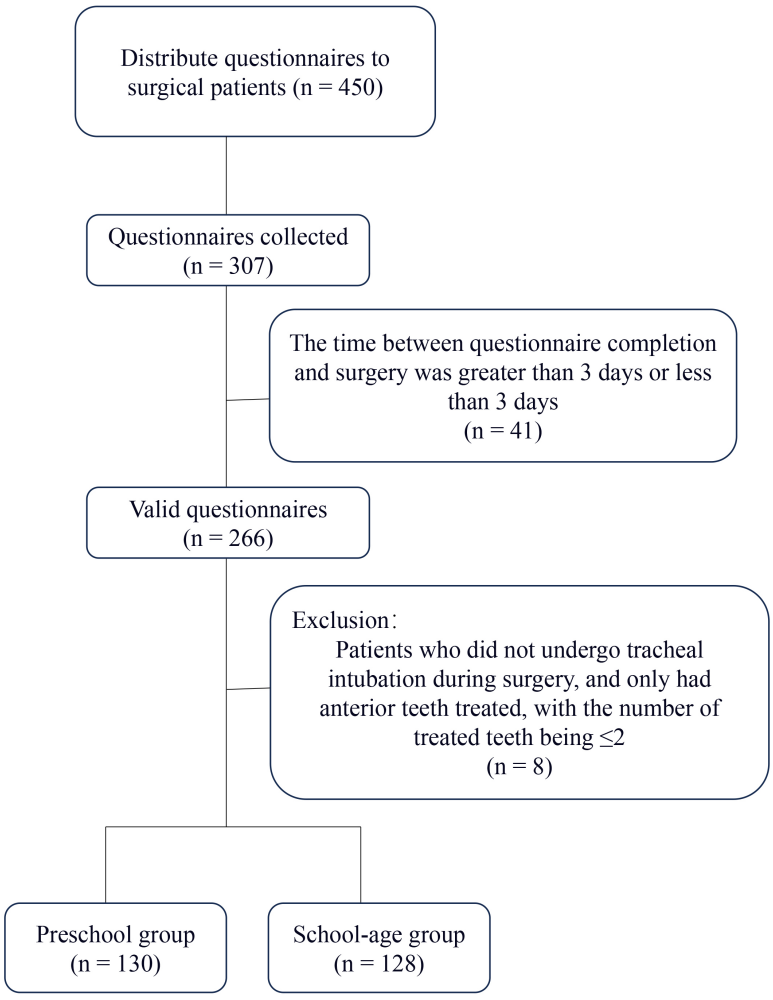

FIGURE 1. Sampling method.

guided to lie down on a dental chair after entering the operation room. With the application of protective fixation and warming measures, children were also subjected to vital sign monitoring via electrocardiogram. A standardized anesthesia protocol of inhalation induction with sevoflurane (sevoflurane vaporizer dial of 6%–8%, with a fresh gas flow rate of 3–6 L/min) was adopted by the anesthesiologist for all children. After pre-charging the circuit, the circuit outlet was connected to an appropriate mask (covering from the chin to the bridge of the nose) and placed over the child's mouth and nose. The child breathed calmly through the sealed mask. Children who were uncooperative were provided with head fixation to avoid forcefully supporting the jaw to prevent painful stimuli and trigger agitation. When children lost consciousness, the sevoflurane vaporizer dial was adjusted to 3%–4% to maintain spontaneous breathing, with assisted breathing if necessary. The fresh gas flow was appropriately reduced to 1–2 L/min to prevent excessive anesthesia and to minimize waste and pollution of anesthetic agents. Meanwhile, a venous access was established for the administration of additional sedatives, analgesics and/or muscle relaxants as needed. Subsequently, the anesthesia machine was connected for mechanical ventilation after nasal endotracheal intubation, with continuous monitoring throughout the procedure. Following the guidance of the American Academy of Pediatric Dentistry, children were given dental treatment by the dental surgeon [6], including caries fillings, restoration of the anterior tooth with transparent crown, aesthetic restoration of the anterior tooth, pulpotomy, root canal therapy, restoration of the primary molar with metal crown, preventive resin fillings, use of pit and fissure sealants and extractions of deciduous and supernumerary teeth. During treatment, gauze packing in the pharyngeal region was utilized to prevent water and other foreign objects from entering the throat and trachea of children. Moreover, invasive procedures and pulp treatments that could cause pain were conducted under local anesthesia. All procedures were completed within 3 h. Postoperatively, children were transferred to the post-anesthesia care unit until meeting the criteria of discharge. Children' guardians were provided with detailed health education by the dental surgeon, with the dental treatment items recorded meticulously.

2.3 Data collection

On the day of the surgery, two trained recorders were responsible for documenting children' general data (name, gender, age, body mass index (BMI)), oral condition (Decayed, Missing, Filled Teeth (DMFT)), treatment details (fillings, root canal therapy, extractions, *etc.*), and anesthesia duration in the hospital's medical record system. Before discharge on the day of the procedure, children' guardians were provided with detailed postoperative instructions by the healthcare personnel, with the explanation of the definitions of various postoperative discomforts (**Supplementary Table 1**), and the distribution of a detailed postoperative instructions (paper version). Children' guardians were informed to complete and submit an online questionnaire three days after operation. The questionnaire included the guardian's general data (relationship to the child, age and education degree of the respondent, *etc.*), postoperative complications (*e.g.*, fever, pain, gastrointestinal symptoms, respiratory symptoms, occlusal discomfort, oral bleeding, negative emotions, drowsiness, *etc.*), and a parental satisfaction survey (treatment outcomes, medical experience and treatment costs).

2.4 Statistical analysis

Data analysis was conducted using SPSS 22.0 software (IBM, Armonk, NY, USA). Normally distributed continuous data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and compared using independent samples *t*-tests between groups. The comparison of counting data employed the chi-square test or Fisher's exact test. The test level was set at 0.05.

3. Results

3.1 General information

This study included 258 children based on the distribution of 307 questionnaires with invalid questionnaires excluded. According to the grouping based on age, there were no statistically significant differences in the general information of the included children and their guardians between the preschool and school-age groups, as shown in Table 1.

3.2 Comparison of intraoperative treatment situations between groups

As shown in Table 2, the preschool group had higher numbers of teeth treated, extractions, root canal treatments and pulpotomies compared to the school-age group, with statistically significant differences (all $p < 0.05$). However, there was no statistically significant difference in the number of full crown treatments between groups ($p > 0.05$).

3.3 Comparison of adverse reactions between groups

Among all children, 84.9% (219/258) experienced one or more adverse reactions. The incidence of adverse reactions was 91.4% and 78.5% in the preschool and the school-age groups, respectively ($\chi^2 = 6.435$, $p = 0.0112$). The most common adverse reaction in both groups was pain (66.7%, 172/258), followed by negative emotions (53.1%, 137/258).

In the preschool group, the most frequent type of adverse reactions was negative emotions, followed by pain, respiratory symptoms and significant occlusal discomfort. While in the school-age group, pain was the most common adverse reaction, followed by negative emotions and respiratory symptoms (Table 3).

Furthermore, children in the preschool group experienced higher incidence of fever, gastrointestinal symptoms, significant occlusal discomfort, pain and negative emotions compared to the school-age group. However, the incidence of respiratory symptoms, oral bleeding and drowsiness was lower in the preschool group than in the school-age group. Statistically significant differences were observed in the comparison of the incidence of fever, significant occlusal discomfort, pain, negative emotions and drowsiness between groups ($p < 0.05$) (Table 3). Relative Risk (RR) analysis among the adverse

TABLE 1. Characteristics of enrolled children and guardians.

	Preschool (n = 130) n (%)	School-age (n = 128) n (%)	*p* value
Child's gender			
Male	71 (54.6)	75 (58.6)	0.508
Female	59 (45.4)	53 (41.4)	
Parent's age			
20–30 yr	19 (14.6)	13 (10.2)	
30–50 yr	108 (83.1)	114 (89.1)	0.323
Over 50 yr	3 (2.3)	1 (0.8)	
Relationship to child			
Mother	113 (86.9)	106 (82.8)	
Father	16 (12.3)	19 (14.8)	0.487
Other relatives	1 (0.8)	3 (2.3)	
Caregiver education background			
No college education	34 (26.2)	35 (27.3)	
College	84 (64.6)	85 (66.4)	0.664
Master's degree or above	12 (9.2)	8 (6.3)	

TABLE 2. Comparison of intraoperative treatment situations between groups.

Number of treatment	Average value		*t*-value	*p*-value
	Preschool group	School-age group		
Teeth treated	15.0 ± 3.7	14.0 ± 3.1	−2.81	0.001*
Extractions	1.8 ± 1.9	3.1 ± 2.7	4.40	0.007*
Root canal	3.3 ± 2.2	1.9 ± 1.6	−5.17	0.005*
Full crown	5.1 ± 2.3	3.3 ± 2.2	0.71	0.778
Pulpotomies	2.0 ± 1.9	1.2 ± 1.6	−3.51	0.025*

**p < 0.05.*

TABLE 3. Comparison of postoperative adverse reactions between groups.

Adverse reaction	Preschool (n = 130, %)	School-age (n = 128, %)	χ^2	*p*	RR[b]
Fever	17 (13.1)	6 (4.7)	5.59	0.018*	2.79
Gastrointestinal symptoms	25 (19.2)	20 (15.6)	5.82	0.445	
Significant occlusal discomfort	30 (23.1)	10 (7.8)	11.47	0.001*	2.96
Respiratory symptoms	34 (26.2)	35 (27.3)	0.16	0.691	
Pain	98 (75.4)	74 (57.8)	8.96	0.003*	1.30
Oral bleeding	3 (2.3)	5 (3.9)	0.15	0.545	
Negative emotions	99 (76.2)	38 (29.7)	55.92	<0.001*	2.56
Drowsiness	13 (10.0)	29 (22.7)	7.58	0.006*	0.44

**p < 0.05; b stands for Relative Risk (RR).*

reactions with a $p < 0.05$ has shown that the preschool children group had a higher risk of fever, significant occlusal discomfort, pain and negative emotions compared to the school-age children group, while the risk of somnolence was lower (Table 3).

According to multiple logistic regression analysis, the number of teeth treated, extracted and pulpotomies were the risk factors of postoperative pain in preschool children; while the number of teeth extracted and pulpotomies related with postoperative pain in school-age children (Tables 4,5).

3.4 Parental satisfaction after DGA

The postoperative satisfaction degrees of parents in both groups were above 90% for all aspects including the medical experience, expected outcomes and general anesthesia. Parents expressed their willingness of choosing DGA again in situations where the same decision needed to be made (under the same conditions). However, regarding treatment costs, 19.2% of parents in the preschool group and 20.3% in the school-age group felt that the costs exceeded their expectations. Parental satisfaction after DGA is shown in Table 6.

4. Discussion

In the clinical setting, general anesthesia becomes a popular option for pediatric dental procedures, which may be related to parents' increasing concern on children' oral health, the introduction of various national policies to promote the development of pediatric oral health services and the maturation of general anesthesia techniques. Pediatric DGA can benefit the restoration of pediatric dental appearance and chewing function to the maximal extent. However, pediatric DGA may induce frequently-occurring postoperative adverse reactions, including pain, fever, significant occlusal discomfort, gastrointestinal symptoms, respiratory symptoms, oral bleeding, negative emotions, drowsiness, *etc.* Typically, these events appear on the first day after operation and gradually alleviate over time [7]. Nevertheless, these adverse reactions may bother children significantly during the perioperative period, causing compromised comfort, quality of life, and even postoperative recovery, also causing parents' anxiety and impacting medical satisfaction. Therefore, active research on postoperative adverse reactions in pediatric DGA is essential for improving the service quality of pediatric oral care clinically.

Consistent with previous studies [8], this study reported that 84.9% of children experienced at least one postoperative adverse reaction, particularly higher in the preschool group than that of the school-age group.

The most common postoperative adverse reaction in this study was pain (66.7%), including 98 preschool children (75.4%) and 74 school-age children (57.8%). As the most common and longest-lasting post-DGA reaction, pain has an intimate association with the number of teeth extracted, root canal treatments performed, the number of prefabricated crowns placed, treatment duration, and surgical complexity. The incidence of post-DGA varied in different studies, ranging between 13% and 95% [8, 9], largely attributed to different populations, treatment procedures and pain assessment methods. Pain is a subjective experience, and the best method for assessment is self-report [10]. Assessing pain in children is challenging due to their limited communication and descriptive abilities. In this study, the Faces Pain Scale-Revised was used to evaluate children' pain through the selection of the facial expression corresponding to the level of pain by children, yielding reliable results. The duration of the surgery [11] and the total number of teeth treated [8] are positively correlated with postoperative pain, with more frequent incidence of postoperative pain when there is longer duration of surgery. It can be interpreted that patients may undergo more traumatic and time-consuming treatments (*e.g.*, pulp therapy, extractions with interim space

TABLE 4. Multiple logistic regression analysis of related factors of postoperative pain in preschool children.

Variables	β	OR	95% confidence interval	p value
Teeth treated	0.32	1.38	1.09–1.74	0.008*
Extractions	0.41	1.51	1.06–2.15	0.023*
Root canal	0.28	1.32	0.98–1.78	0.062
Full crown	−0.55	0.86	0.65–1.13	0.280
Pulpotomies	0.37	1.45	1.06–1.98	0.020*

$p < 0.05$, $R^2 = 0.36$. OR: odds ratio.

TABLE 5. Multiple logistic regression analysis of related factors of postoperative pain in school-age children.

Variables	β	OR	95% confidence interval	p value
Teeth treated	0.25	1.28	0.96–1.72	0.093
Extractions	0.52	1.68	1.12–2.53	0.013*
Root canal	0.12	1.13	0.79–1.61	0.503
Full crown	−0.31	0.73	0.52–1.02	0.068
Pulpotomies	0.38	1.46	1.01–2.11	0.046*

$p < 0.05$, $R^2 = 0.29$. OR: odds ratio.

TABLE 6. Parental satisfaction after DGA.

Questions	Yes n (%)		No n (%)	
	Preschool	School-age	Preschool	School-age
Do you think your child's oral condition has met the expected treatment outcome?	126 (96.9)	123 (96.1)	4 (3.1)	5 (3.9)
Are you satisfied with your child's dental treatment under general anesthesia?	127 (97.7)	128 (100.0)	3 (2.3)	0 (0)
If you had to choose again (under the same conditions), would you still choose dental treatment under general anesthesia for your child?	124 (95.4)	124 (96.9)	6 (4.6)	4 (3.1)
Are you satisfied with the medical experience this time?	119 (91.5)	123 (96.1)	11 (8.5)	5 (3.9)
Did the treatment costs exceed your expectations?	25 (19.2)	26 (20.3)	105 (80.8)	102 (79.7)

maintenance) during a longer surgical period, leading to cumulative discomfort and more likely postoperative pain. Additionally, multiple metal prefabricated crowns, not using local anesthesia, extractions, root canal treatments, and gender are also risk factors for postoperative pain in children [11–13]. In this study, children who experienced the probability of postoperative pain had more teeth treated, more teeth extracted and pulpotomies.

Furthermore, 53.1% of children experienced negative emotions (*e.g.*, crying, sadness, irritability, tension, anxiety and excitement) postoperatively, showing significantly higher incidence in preschool children (n = 99, 76.2%) than that of school-age children (n = 38, 29.7%). Therefore, special attention should be paid to the postoperative psychological changes of children, as they often take longer to recover than physical discomfort [12]. Due to limited cognitive, understanding and emotional regulation abilities, preschool children may have postoperative emotional fluctuations and hence negative emotions when facing unfamiliar environments and medical personnel, confusion and anxiety about the necessity of surgery, the postoperative recovery process, and separation from parents during surgery. School-age children, on the other hand, have better understanding in various aspects, and can usually clearly express their confusion and discomfort to receive timely resolution. Additionally, preschool children had more root canal treatments, metal prefabricated crowns, and total treated teeth, leading to a higher postoperative pain rate compared to school-age children ($p < 0.05$). This condition can be regarded as key contributor of more negative emotions in preschool children. The use of sevoflurane for anesthesia induction has been reported to possibly trigger postoperative agitation and irritability [14]. Hence, the number of extractions under DGA has a significant impact on children' postoperative fear [12].

Similar to previous research [15], there was no significant difference in the incidence of postoperative respiratory symptoms between preschool and school-age children in this study (26.2% *vs.* 27.3%). Respiratory symptoms mainly include nasal bleeding or pain, throat pain, and hoarseness. Risk factors for postoperative sore throat mainly included repeated intubation attempts, visible blood on the tip of the laryngoscope during intubation, and prolonged intubation time [16]. In this study, children would undergo DGA via nasal intubation, with greater risk of damage to their delicate nasal mucosa during intubation, leading to postoperative respiratory symptoms such as nasal bleeding and pain. Anesthesiologists with rich clinical experience can avoid multiple intubation attempts, perform gentle maneuvers and reduce intubation time, thereby reducing the risk of postoperative respiratory symptoms.

Postoperative significant occlusal discomfort was reported in 30 preschool children (23.1%) and 10 school-age children (7.8%). It primarily stems from the placement of metal prefabricated crowns, where multiple decayed teeth are restored and metal crowns are placed in one session, which may alter children' occlusal relationship in the short term to induce significant occlusal discomfort. In this study, no significant difference was found in metal prefabricated crowns between preschool and school-age children, possibly owing to better understanding of the temporary occlusal discomfort caused by dental treatment and hence no reporting in school-age children. Generally, after operation, children can effectively restore their occlusal relationship through self-adjustment and adaptation within 2 to 4 weeks over time [17].

In this study, only 2.3% of preschool children and 3.9% of school-age children reported postoperative oral bleeding, much lower than those reported in previous studies [18, 19]. Postoperative bleeding is generally attributed to the damage to the gums during extractions, oral surgery and the preparation of metal prefabricated crowns. Postoperative oozing is often mistaken for oral bleeding by parents [13]. To reduce parental anxiety, postoperative guidance on distinguishing between postoperative oozing and oral bleeding should be explained in detail to parents to avoid their confusion. Detailed postoperative guidance might be one reason for the low reported incidence of oral bleeding in this study. In addition, postoperative bleeding may also be reduced through intraoperative use of epinephrine-containing local anesthesia, absorbable hemostatic gelatin sponges and wound suturing.

The probabilities of fever (13.1%, 4.7%), gastrointestinal symptoms (19.2%, 15.6%), and drowsiness (10%, 22.7%) in this study were similar to previous report [20]. The fever was mild and temporary, possibly due to inflammatory response or reaction to anesthetic drugs. The higher incidence in preschool children may be related to their younger age and weaker thermoregulation ability. Therefore, it is more important to closely

monitor temperature changes of younger children, with the adjustment of environmental temperature and humidity in the operating room during surgery. There was no statistical difference in gastrointestinal symptoms between groups. The most common symptoms were nausea and vomiting, usually related to preoperative fasting, use of anesthetic drugs and surgical stimulation. School-age children were drowsier postoperatively compared to preschool children, yet with low incidence in both groups. Drowsiness is a normal physiological response after general anesthesia, and parental anxiety on this issue can be mitigated by providing corresponding postoperative instructions.

The postoperative parental satisfaction was above 90% for all aspects, including medical experience, expected outcomes and general anesthesia. Parents indicated their willingness of choosing DGA again when necessary (under the same conditions). Therefore, surgery under DGA is highly recognized and worth promoting, which can deal with children' oral problems in a one-time, comfortable, painless and convenient manner. However, 19.2% of parents in the preschool group and 20.3% in the school-age group felt that the costs exceeded their expectations. The acceptance on treatment costs should be improved by strengthening preoperative cost communication and psychological construction of parents in advance. Additionally, dental treatment costs can also be saved by enhancing oral health education and prevention, and promoting good oral hygiene practices in the future.

However, this study has some limitations. Firstly, it is a prospective cohort study, with potential information bias between parents/caregivers during questionnaire filling. It might differ somewhat from the children' subjective feelings, which is a common issue in pediatric surveys. Secondly, the sample size of the study may not be large enough to fully represent the entire population of children undergoing DGA for dental procedures. Thirdly, the study mainly focused on the short-term postoperative adverse reactions, and the long-term effects of DGA on children's oral health and psychological well-being were not fully explored. Nevertheless, Findings in this study may benefit the management of postoperative adverse reactions in pediatric DGA. For children of different age groups, it is useful to employ postoperative targeted explanations of common adverse reactions and their possible causes, along with corresponding management strategies, which can effectively reduce parental anxiety and provide better postoperative care for children.

5. Conclusions

In summary, children may experience extremely high adverse reactions after dental procedures under DGA, with pain being the most common, followed by negative emotions, gastrointestinal symptoms, respiratory symptoms and significant occlusal discomfort. Preschool children may experience more reactions due to their higher number of treated teeth, root canal treatments, and restoration with metal crown. Therefore, preschool children should be attached more attention to and provided with effective soothing measures in the clinical setting.

ABBREVIATIONS

DGA, dental general anesthesia; BMI, body mass index; DMFT, Decayed, Missing, Filled Teeth; RR, Relative Risk.

AVAILABILITY OF DATA AND MATERIALS

All data and materials are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

RY and LZ—designed the research study. YW and DY—collected the data. SL and XQY—analyzed the data. LZ and XQY—prepared figures and tables. LZ and QL—drafted the manuscript. RY—revised and refined the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Written informed consent related to the use of relevant data was obtained from the patients' parents or guardians. This project was approved by the Ethics Committee of West China Hospital of Stomatology, Sichuan University (Approval No.: WCHSIRB-CT-2023-317).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/2006247210180591616/attachment/Supplementary%20material.docx.

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