Clinical effectiveness of inhalation conscious sedation with nitrous oxide and oxygen for dental treatment in uncooperative paediatric patients during COVID-19 outbreak

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Abstract

Aim The aim of this study was to evaluate the features of inhalation conscious sedation for urgent dental treatments in uncooperative paediatric patients during COVID-19 outbreak.

Methods Forty-two uncooperative patients, attending primary and secondary schools, were submitted to emergency dental treatments with inhalation conscious sedation using nitrous oxide and oxygen during COVID-19 pandemic. Collected data included: number of working sessions, success/failure, adverse events, side effects, number of teeth treated; type of dental procedure. Parents filled in an e-mailed questionnaire on post-discharge children status to evaluate: pain; crying; fever; vomiting; headache; drowsiness; excitability; irritability; ability to eat; need for drugs.

Results One working session was carried out in 29 patients, 2 working sessions were carried out in 6 patients and 3 working sessions were carried out in 7 patients. Success rate was 87.1%. In relation to success, there was no statistically significant difference between males and females, healthy and disabled patients, respectively; while there was a statistically significant difference between patients attending primary and secondary schools (p=0.023). No adverse events occurred. The most frequent side effect was nausea. In relation to side effects, there was no statistically significant difference between males and females, healthy and disabled patients, patients attending primary and secondary schools, respectively. In relation to e-mailed questionnaires on post-discharge children status, 29.6% of the patients had pain, 22.2% vomited, 14.8% had headache, 18.5% experienced drowsiness, 29.6% failed to eating normally, 35.2% needed to take drugs. None of the patients cried, had a fever, exhibited irritability and excitability.

Conclusions Inhalation conscious sedation is a safe, practical and effective procedure with minimal side effects to perform emergency dental treatments in uncooperative paediatric patients during COVID-19 outbreak.

KEYWORDS Inhalation conscious sedation; Children; Paediatric dentistry; COVID-19; Nitrous oxide.

Introduction

COVID-19 is a Severe Acute Respiratory Syndrome (SARS) caused by SARS-CoV-2 virus [Rabaan et al., 2020], which has globally affected many countries. In adults, signs and symptoms of COVID-19 may appear two to 14 days after exposure and can include: fever, cough, shortness of breath or difficulty breathing, tiredness, body aches, runny nose, sore throat. The severity of COVID-19 symptoms can range from very mild to severe. Complications can include pneumonia in both lungs, organ failure and death [Ferrazzano et al., 2020a]. Paediatric COVID-19 infection is reported to be relatively mild in symptoms, when compared to adults and adolescents, and children are also reported to have a better prognosis [Al-Halabi et al., 2020]. The common transmission routes of this novel virus include direct transmission through coughing, sneezing, and droplet inhalation, as well as contact transmission via oral, nasal, and eye mucous membranes [Bahramian et al., 2020].

Because of the long incubation period (2–14 days), and because children can be asymptomatic or present with mild, nonspecific symptoms, all paediatric dental patients and parents should be considered as potential carriers of COVID-19. This leaves dental professionals in potentially high-risk situations, so it is necessary to ensure their safety, not only to protect patient health, but also to safeguard themselves from viral infection and to avoid viral transmission [Mallineni et al., 2020; Ferrazzano et al., 2020a].

During the first pandemic outbreak, in Italy, routine dental practice was postponed and only severe dental paediatric emergencies (such as discomfort, pain, swelling, life endangering dentigerous infection, traumatic dental injuries, etc.) were performed [Ferrazzano et al., 2020a; Paglia, 2020]. Moreover, given the challenges of working with a paediatric population, including anxiety and lack of compliance, it is not unrealistic that sedative approach may be required. In fact, dental anxiety is a common problem, which can affect people of all ages, but appears to develop mostly in childhood and adolescence. Some children exhibit fears of specific dental treatments, other children have a more general anxiety associated with the dental setting [Porritt et al., 2012; Hmud

and Walsh, 2009].

In clinical paediatric dentistry, dental anxiety and fear might represent a major behavioural management challenge for children, parents, and dentists [Garrocho-Rangel et al., 2018; Bulut and Bulut, 2020]. If the level of fear is incongruent with the circumstances and the patient is not able to control impulses, disruptive behaviour is likely to require a sedative approach [Ferrazzano et al., 2019; Ferrazzano et al., 2020b; Garret-Bernardin et al., 2017].

The risk of transmission of COVID-19 associated with inhalation sedation with nitrous oxide and oxygen has been reported as being low [Ilyas et al., 2020]. So, if urgent dental treatment is to be provided with inhalational sedation, usual best practice should continue to apply, including changing of the tubing, thorough cleaning of the operative room and ventilation between patients [Royal College of Surgeons of England, 2020].

Nitrous oxide is a colorless and virtually odourless gas with a faint, sweet smell. It is an effective analgesic/anxiolytic agent causing central nervous system (CNS) depression and euphoria with little effect on the respiratory system [American Academy of Paediatric Dentistry, 2018]. Sub-anaesthetic concentrations of N_2O produce only analgesic and anxiolytic effects without unconsciousness: the patient must retain the ability to respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation [Emmanouil and Quock, 2007]. All vital signs are stable, there is no significant risk of losing protective reflexes, and the patient is able to return to pre-procedure mobility. Nitrous oxide has rapid uptake and it is excreted quickly from the lungs, allowing for both rapid onset and recovery (two to three minutes). It causes minimal impairment of any reflexes, thus protecting the cough reflex. It exhibits a superior safety profile with no recorded fatalities or cases of serious morbidity when used within recommended concentrations [American Dental Association, 2019].

The aim of the use of inhalation sedation is to help fearful and/or anxious patients feel more relaxed, thereby facilitating patient behavior management during medical and dental procedures [Daher et al., 2012]. The American Academy of Paediatric Dentistry recognises nitrous oxide/oxygen inhalation as a safe and effective technique to reduce anxiety, produce analgesia, and enhance effective communication between patient and health care provider [American Academy of Paediatric Dentistry, 2004].

Based on these considerations, the primary goal of this study was to assess the clinical effectiveness of inhalation conscious sedation with nitrous oxide and oxygen for urgent dental treatments in uncooperative paediatric patients during COVID-19 outbreak. The secondary outcome was related to patient safety, considering adverse events and side effects.

Materials and methods

This study was approved by the Research Ethics Committee of the "Federico II University" Faculty of Dentistry, Naples, Italy (PT n° 33/19). The study was carried out by the Department of Neuroscience, Reproductive and Oral Sciences, School of Paediatric Dentistry, University of Naples "Federico II", Naples, Italy from March to May 2020.

In accordance with the Declaration of Helsinki, a total of 42 uncooperative children with American Society of Anaesthesiologists status I or II, attending primary and secondary schools, undergoing emergency dental treatment under inhalation conscious sedation with nitrous oxide and oxygen, were randomly recruited. For these patients, behavioural techniques have been unsatisfactory.

The exclusion criteria were: children with American Society of Anaesthesiologists status III, IV and V, children with intestinal occlusion, severe obstructive pulmonary disease; severe emotional disturbances or drug-related addictions; acute otitis media, recent drainage of the eardrum and adenoid pathology.

Patients can eat up to two hours prior to the dental appointment.

The treatment was performed in day hospital, so the patient was treated and discharged during the same day. On this occasion, the purpose and modalities of the study were shown to parents and paediatric patients and they were asked to participate voluntarily in the study. The consent to the processing of personal data and the informed consent to the medical act before proceeding to any type of intervention were obtained by parents.

First of all, phone triage was organised to obtain all the possible information both on child health status and on oral symptoms, in order to understand if dental procedure represented an urgent need and could not be postponed. In case of not postponing dental emergency, once the child and one accompanying person arrived at the hospital, body temperature was measured, using infrared thermometers. Then, they were provided with medical masks and shoe cover. Child and accompanying person were requested to wash hands with water and soap and to apply an alcoholic solution on hands later. Furthermore, the accompanying person re-answered the questions on child health status [Ferrazzano et al., 2020a].

Dental emergency appointments were organised in order that no more than one paediatric patient, together with the accompanying person, waited in the preoperative room at a time. Dental staff members checked their body temperatures before work. Hand washing was implemented. In particular, dental practitioners washed their hands before child examination, before and after dental treatments. According to the indications of the National Association of Italian Dentists (ANDI), personal protective equipment, including eyewear, masks, gloves, caps, face shields, surgical clothes, shoe-cover, were worn [Ferrazzano et al., 2020a; Paglia, 2020].

At the beginning, 100% oxygen was delivered through the nasal mask for 5 minutes. Subsequently, 30% nitrous oxide was delivered in increments of 5–10% up to a maximum of 50% to obtain the desired level of sedation (patients should be silent and almost immobile, but able to understand and respond to verbal commands). After an induction period of 8 minutes, dental treatment was performed. At the end of dental treatment, 100% oxygen was delivered for 5 minutes [Galeotti et al., 2016].

Disposable nasal hoods and tubing were used for all patients to minimise the risk of viral transmission in the decontamination process, with treatment being carried out as efficiently as possible to minimise any risk of aerosol production [Ilyas et al., 2020].

During dental procedure, the following data were collected: number of working sessions, success/failure, adverse events, side effects, number of teeth treated and type of dental procedure performed.

At discharge, parents were invited to complete by e-mail a questionnaire on post-discharge children status during the next 12h to evaluate: post-operative pain; crying; fever;

Characteristics of the patients	Number of working sessions	Success	Failure	p-value
Gender				
Male	21	18	3	0.82
Female	41	36	5	ns
School attended				
Primary	31	24	7	0.023*
Secondary	31	30	1	
Health Status				
Healthy	58	51	7	0.45
Disabled	4	3	1	ns

*P-values based on chi-square tests: **P < 0.01, strong statistical significance; *P < 0.05, statistical significance; ns, non-significant*

TABLE 1 Success in relation to the characteristics of the patients.

Characteristics of the patients	Number of working sessions	Side effects	No side effects	p-value
Gender				
Male	21	3	18	0.54
Female	41	4	37	ns
School attended				
Primary	31	5	26	0.23
Secondary	31	2	29	ns
Health Status				
Healthy	58	6	52	0.37
Disabled	4	1	3	ns

*P-values based on chi-square tests: **P < 0.01, strong statistical significance; *P < 0.05, statistical significance; ns, non-significant*

TABLE 2 Side effects in relation to the characteristics of the patients.

vomiting; headache; drowsiness; excitability; irritability; ability to eat; need to administer drugs at home.

The results obtained were subjected to statistical processing using Chi-Square test through the SPSS computer programme. Significance level was set up at p=0.05.

Results

Forty-two patients (18 males and 24 females), attending primary and secondary schools, underwent inhalation conscious sedation with nitrous oxide and oxygen to perform emergency dental treatments from March to May 2020 during COVID-19 outbreak.

The average age of the sample was 9.14± 2.38. The study population was composed of 38 healthy patients and 4 disabled patients (patients with mild psycho-motor disability).

In 29 patients one working session was performed, in 6 patients 2 working sessions were performed and in 7 patients 3 working sessions were performed (for a total of 62 working sessions). The overall success rate was 87.1% (54 out of 62; only 8 working sessions failed as dental therapy was not completed due to the patient's lack of cooperation). Twenty-one working sessions (33.8%) were carried out in male patients with a success of 85.7% and 41 working sessions (66.2%) in female patients with a success of 87.8%. In relation to success, there was no statistically significant difference between males and females.

Fifty percent of the working sessions were carried out in patients attending primary school with 77.4% of success, 50% in patients attending secondary school with 96.7% of success.

Characteristics of dental treatments	Number of working sessions	Side effects	No side effects	p-value
CT				
1	12	2	10	0.65
>1	10	1	9	ns
ET				
1	9	1	8	0.88
>1	11	1	10	ns
DF				
1	49	4	45	0.38
>1	5	1	4	ns
Dental arch				
Upper	22	3	19	0.76
Lower	24	4	20	ns

*CT: teeth submitted to conservative therapy; ET: extracted teeth; DF: different types of dental treatments performed. P-values based on chi-square tests: **P < 0.01, strong statistical significance; *P < 0.05, statistical significance; ns, non-significant.*

TABLE 3 Side effects in relation to the characteristics of dental treatments.

In relation to success, there was a statistically significant difference between patients attending primary school and patients attending secondary school (p=0.023).

Four working sessions were performed in disabled patients (1 session failed) and 58 working sessions were performed in healthy patients with only 12.1% of failure. In relation to success, there was no statistically significant difference between healthy and disabled patients. Table 1 summarizes the statistical significance of success in relation to the characteristics of the patients. No adverse events occurred.

Side effects occurred in 7 of the total sessions (11.3%) with nausea (3.1%), following by nausea and vomiting (1.6%) and vomiting (1.6%). The chi-square test showed that, in relation to side effects, there was no statistically significant difference between males and females, healthy and disabled patients, patients attending primary and secondary schools, respectively. The statistical analysis of the side effects in relation to the patient's characteristics is summarised in Table 2.

During the study, 98 procedures were performed: 35 conservative therapies (restorative/endodontic), 37 dental extractions, 2 dental scaling and 24 other surgical procedures.

The number of teeth treated on average, in each working session, was 1.43 ± 1.1. In 12 sessions (22.2%) conservative therapy was performed on 1 tooth, in 8 sessions (14.8%) conservative therapy was performed on 2 teeth and in 2 sessions (3.8%) conservative therapy was performed on more than 2 teeth. In 9 sessions (16.7%) only one tooth was extracted, in 6 sessions (11.1%) 2 teeth were extracted and in 5 sessions (9.3%) more than 2 teeth were extracted. There was no statistically significant correlation between the number of teeth submitted to conservative therapy and side effects. There was no statistically significant correlation between the number of extracted teeth and the side effects. During dental scaling and other surgical procedures no side effects occurred.

In 49 working sessions (90.7%) only one type of dental procedure was performed, in 4 working sessions (7.4%) two types of procedures were performed, in one work session (1.9%) three different dental treatments were performed. There was no statistically significant correlation between the number of different dental treatments performed and the side effects.

	Gender		p-value	School attended		p-value	Health state		p-value
	M	F		Primary	Secondary		Healthy	Disabled	
Post-discharge children status									
Pain									
Yes	7	11	0.59	14	2	0.02*	14	2	0.25
No	14	30	ns	17	29		44	2	ns
Vomiting									
Yes	3	10	0.35	9	4	0.12	12	0	0.31
No	18	31	ns	22	27	ns	46	4	ns
Headache									
Yes	3	5	0.82	2	6	0.13	6	2	0.02*
No	18	36	ns	29	25	ns	52	2	
Drowsiness									
Yes	5	7	0.35	4	6	0.49	9	1	0.62
No	16	34	ns	27	25	ns	49	3	ns
Difficulty to eat									
Yes	7	10	0.45	13	2	0.001**	14	1	0.97
No	14	31	ns	18	29		44	3	ns
Need to take drugs									
Yes									
No	10	11	0.10	12	4	0.02*	17	2	0.38
	11	30	ns	19	27		41	2	ns

*P-values based on chi-square tests: **P < 0.01, strong statistical significance; *P < 0.05, statistical significance; ns, non-significant*

TABLE 4 Statistical analysis of post-discharge children status in relation to patient's characteristics.

In 40.7% of cases (22 working sessions), the treatment was performed on the upper dental arch; in 44.4% of cases (24 working sessions) on the lower dental arch and in 14.8% (8 working sessions) of cases on both dental arches. In relation to side effects, there was no statistically significant difference between treatments performed on the upper dental arch and treatments performed on the lower dental arch. Table 3 summarises the onset of side effects in relation to the characteristics of dental treatments.

In relation to the e-mailed questionnaires completed by the parents on post-discharge children status, 29.6% of the patients had pain, 22.2% vomited, 14.8% had headaches, 18.5% showed drowsiness, 29.6% failed to eat normally, 35.2% needed to take drugs. No patient cried, had fever, showed excitability and irritability. There was no statistically significant difference between males and females in relation to post-discharge children status. There was a statistically significant correlation between post-discharge pain and type of school attended (p=0.02) and between post-discharge difficulty to eat and type of school attended (p=0.001) and between post-discharge need to take drugs and type of school attended, respectively (p=0.02). There was a correlation between post-discharge headache and the patient's health status (p=0.02). Table 4 summarises the statistical analysis of post-discharge children status in relation to patient's characteristics.

In relation to the type of dental treatment performed, there is a correlation between: conservative therapy and no vomiting (p=0.037) and no need to take drugs (p= 0.001), respectively; extractions and post-discharge pain (p=0.0012), no post-discharge headache (p=0.047) and difficulty to eat (p=0.0012), respectively; other surgical treatments and post-discharge pain (p=0.001), difficulty to eat (p=0.001) and need to take drugs (p=0.001), respectively. There is no correlation between post-discharge children status and dental arches treated. Table 5 summarized the statistical analysis of the post-discharge children status in relation to dental procedures performed.

Discussion

The unpredictability of COVID-19 infection in children, in addition to the reports of carrier status of the SARS-CoV-2, may represent a challenge for paediatric dentists [Al-Halabi et al., 2020].

The management of oral health, including that of children, is part of planned drop in health care services provided during COVID-19 epidemic. This becomes more serious when vulnerable classes (physically and economically) are involved. For example, with children belonging to the socio-economically most disadvantaged classes and those with special needs, a reduced provision of dental care (especially public care) leads to a worsening of oral health status [Cianetti et al., 2020; Ferrazzano et al., 2016].

Dental pain may have a severe impact on these children and their families with evidence of adverse behaviours. Furthermore, children with underlying medical conditions should have special consideration due to the increased risk of developing complications arising from any subsequent untreated dental infections [Al-Halabi et al., 2020].

In this study, inhalation conscious sedation with nitrous oxide and oxygen was used to obtain anxiolysis and allowed to carry out emergency dental treatments in uncooperative paediatric patients (patients with behavioural difficulties, such as young children, patients with dental anxiety or phobia, and patients with mild psycho-motor disability) during COVID-19 outbreak.

To explain the small sample recruited in the study it should be considered that, in order to correctly carry out all the pre and postoperative sanitisation procedures and to avoid crowding of patients (and parents/caregivers) in the waiting

Post-discharge children status	Conservative therapy		p-value	Extraction		p-value	Other surgical treatments		p-value
	Yes	No		Yes	No		Yes	No	
Pain Yes No	3 15	13 23	0.14 ns	14 2	15 23	0.0012**	12 2	4 36	0.001**
Vomiting Yes No	1 17	11 25	0.037*	6 10	6 32	0.079 ns	2 12	10 30	0.41 ns
Headache Yes No	4 4	4 32	0.28 ns	0 16	8 30	0.047*	4 10	4 36	0.09 ns
Drowsiness Yes No	1 17	9 27	0.083 ns	3 13	7 31	0.97 ns	4 10	6 34	0.26 ns
Difficulty to eat Yes No	3 15	13 23	0.14 ns	14 2	15 23	0.0012*	12 2	4 36	0.001**
Need to take drugs Yes No	0 18	19 17	0.001**	6 10	13 25	0.82 ns	11 3	8 32	0.001**

*P-values based on chi-square tests: **P < 0.01, strong statistical significance; *P < 0.05, statistical significance; ns, non-significant.*

TABLE 5 Statistical analysis of the post-discharge children status in relation to dental procedures performed.

room, the total number of patients treated daily, depending on the organization of each single dental office, was reduced [Cianetti et al., 2020]. Moreover, only urgent dental treatments were performed in non-cooperating paediatric patients.

The overall success rate of dental treatments performed with the aid of inhalation conscious sedation was 87.1%, in agreement with other studies in the literature that found a similar success rate [Galeotti et al., 2016; Soldani et al., 2010].

The success rate was independent from the patient's gender, in accordance with the scientific literature [Hennequin et al., 2012].

The age of patients was an important factor in determining cooperation during the treatment, in fact in patients attending primary school, the overall success rate was 77.4%, while in patients attending secondary school, the overall success rate was 96.7%; this showed that this sedative technique allowed dental treatments to be completed more successfully in older patients, because they were able to better communicate with the operator and respond to verbal commands [Soldani et al., 2010]. Furthermore, in relation to success, in this study, there was no statistically significant difference between healthy and disabled patients. This result was in contrast with Galeotti et al., [2016] who reported that disability, impairing communications, intellectual functioning, and linguistic development made difficult to provide quality dental care. In fact, a disabled patient could not be able to breathe adequately through a nasal mask or to tolerate unpleasant and long dental procedures. This contrasting result may be related to the limited number of disabled patients considered; moreover, the disabled patients considered in this study had only mild psycho-motor disability.

In terms of safety, no adverse events have occurred in accordance with the literature, in which serious adverse events were rarely reported. Diffusion hypoxia has been identified as a potential complication of treatment with nitrous oxide. For this reason, some authors have advocated a period of oxygen therapy immediately following the cessation of nitrous oxide inhalation. However, several studies have failed to demonstrate diffusion hypoxia after nitrous oxide inhalation [Faddy and Garlick, 2005]. Serious adverse effects such as hypotension and oxygen desaturation have not been shown to occur during treatment with nitrous oxide [Faddy and Garlick, 2005]. It seems that hypoxia and O_2 desaturation occurred after the use of inhalation sedation with nitrous oxide and oxygen are most likely to be due to an association with other drugs, leading to respiratory depression, rather than to the N_2O itself [Kanagasundaram et al., 2001].

Moreover, tolerance of inhalation sedation with nitrous oxide and oxygen was extremely good, with only 11.3% of sessions reporting side effects. The low rate of side effects reported in this study was in accordance with previous studies. The onset of side effects was not related to the patient's characteristics and dental treatments performed. In fact, nitrous oxide may cause emesis by stimulation of the sympathetic system, pressure volume changes in the middle ear, and alteration of gastric myoelectrical activity, so control of nausea and vomiting during inhalation sedation was a specific challenge [Hennequin et al., 2012].

In this study, post-discharge children status was also recorded. In relation to the post-discharge children status, there was statistically significant difference between patients attending primary school and patients attending secondary school, respectively. In the 12 hours post-treatment in fact, parents reported that patients attending primary school experienced pain, difficulty to eat and need to take drugs. However, it is difficult to determine if these occurrences were related to the sedation method employed, the procedure difficulty, or other unknown factors (such as age of patients). Furthermore, in relation to post-discharge children status, there was a statistically significant difference between healthy and disabled patients; in fact, disabled patients experienced post-discharge headache in 50% of cases. This is in accordance

with Castéra et al. [2001], who demonstrated a higher incidence of headache in patients treated with 50% nitrous oxide.

In relation to the dental treatments performed, post-discharge children status alterations occurred mostly during extractions and other surgical procedures. This could be independent of the type of sedation used, but could depend on the most invasive dental treatments carried out. In fact, post-discharge pain, difficulty to eat, need to take drugs occurred very frequently following surgical interventions regardless of the type of sedative technique used [Soldani et al., 2010].

Conclusion

In case of dental emergencies, for those children not accepting treatment in the chair, dental treatment performed in public hospitals under inhalation sedation with nitrous oxide and oxygen has been the best therapeutic choice to provide a safe and effective procedure during COVID-19 pandemic.

The use of inhalation conscious sedation has been shown to be beneficial in the reduction of dental anxiety. In fact, during inhalation sedation, patients are submitted to dental care, while nitrous oxide induces relaxation. This allows the dentist to complete dental treatments in uncooperative paediatric patients in complete autonomy.

The results suggest that uncooperative paediatric patients (patients with behavioural difficulties, such as young children, patients with dental anxiety or phobia, and patients with mild psycho-motor disability), who need emergency dental treatments, could be successfully treated using inhalation conscious sedation with nitrous oxide and oxygen also in the private practice.

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