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A review of the use of general anaesthesia in the treatment of early childhood caries

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Abstract
Early childhood caries is a worldwide healthcare issue in both developed and developing nations. If untreated, it causes short- and long-term consequences that impair the quality of life and wellbeing of the affected families. As a result, the healthcare professional has access to a wide range of preventative and therapeutic strategies to combat this dangerous form of caries. When a young kid appears with substantial tooth damage and demonstrates a lack of cooperation that is incompatible with standard dental office care, general anaesthesia is utilized in select situations after behavioral interventions. Any beneficial outcomes, though, might eventually be lost if there isn't sufficient follow-up.

Keywords: Child, preschool, dental caries, general anesthesia, oral health, quality of life

Introduction
Scientific studies have repeatedly shown that dental caries in adults and children has significantly increased over the world over the past few decades [1]. One of the most common chronic and contagious disorders affecting kids worldwide is early childhood caries (ECC) [2]. ECC is five and seven times more common than asthma and hay fever, respectively, per the inaugural General Surgeon's Report on Oral Health in America [3]. Untreated primary tooth caries, which affects 621 million kids globally, was the tenth most common ailment according to statistics from 2010 [4]. Despite the extensive array of preventative interventions and therapies available, ECC remains a significant health risk and significant challenge. The multifactorial aetiologies of this condition and their connection to socioeconomic and

An overview of early childhood caries
The AAPD defines ECC as the presence of one or more decayed (non cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child aged 71 months or younger. Any sign of smooth surface caries in children younger than 3 years of age is indicative of severe ECC [5]. ECC leads to pain, possible infection, destruction of dental surfaces, deterioration of life quality of children (difficulties in speaking, eating, sleeping, delayed physical growth), and school and social disruption for kids and their caregivers if left untreated [6, 7]. The most used preventive measures in managing ECC, in addition to awareness and educational programs, remains the topical application of antimicrobial agents (such as fluoride gels, fluoride varnishes, sealants, chlorhexidine, xylitol, povidone iodine, and silver compounds) [8]. Extensively cavitated ECC lesions pose a growing challenge in terms of treatment. Where possible, minimally invasive techniques are advantageous [9]. Despite improvements in dental materials and procedures, there is no agreement on the optimum traditional restoration approach [8]. It is typically suggested to seal teeth with a stainless-steel crown after pulp treatment. Considering the great range of treatments available, a crucial component of child management is ensuring that the proposed operations in the dental chair are accepted by the kid without fear or apprehension on their part. Children differ in their attitudes and temperaments due to variances in their physical, emotional, and social maturation Table 1. Classification of behavioral management techniques in pediatric dentistry

Table 1: Classification of behavioral management techniques in pediatric dentistry

Nonpharmacological	Pharmacological
- Universally accepted: + Verbal communication + Nonverbal communication + Formal relaxation techniques: pre-appointment use of imagery and visual help, direct observation of other children receiving dental treatment. + Tell-Show-Do + Ask-Tell-Ask + Voice control + Positive reinforcement, descriptive praise + Distraction + Parents presence/absence + Behavior shaping: desensitization, modelling - Non universally accepted: + Whole restraint + Hand Over Mouth + Protective stabilization, partial or total.	- Minimal sedation (Anxiolysis) - Moderate sedation (Conscious sedation) - Dissociative sedation - Deep sedation - General anesthesia

The focus of behavioural management techniques has evolved in the latter part of the 20th century to a greater emphasis on communication and empathy in order to give the best possible painless and stress-free treatment in a conventional dentistry environment [10]. Depending on their professional training, experience, communication skills, patient specifics, and parental engagement, dental practitioners have a variety of non-pharmacological treatments to select from (Table 1). In certain cases, the obstacles the dentist faces in the dental chair force him or her to use inefficient disease-fighting tactics. As a result, pharmacological management has become more popular in order to give parents and kids a safer atmosphere. General anaesthesia (GA) is the most extreme kind of sedation [11]. This type of individualized dental treatment has been used more often in the last decades to provide high quality preventive or restorative treatment in one appointment.

General anesthesia in the management of ECC

Definition and indications of GA

Medical professionals refer to GA as a controlled drug-induced state of unconsciousness during which patients are rendered incapable of being awakened, even by unpleasant stimuli, and lose their defence mechanisms. Cardiovascular function may be hampered, and independent ventilatory function is typically insufficient [12, 13]. Just two non-exclusive indications for GA are listed in the most recent UK national clinical recommendations in paediatric dentistry, which were released by the Royal College of Surgeons in 2008 [14]:

- When the child needs to be fully anaesthetized before dental treatment procedures can be attempted.
- When the surgeon needs the child fully anaesthetized before dental treatment can be provided

This might seem ambiguous; however, this rationale states that the use of GA should provide a safe, painless, anxiety-free, and humane environment for effective dental care. The dental provider and child's care giver should consider the following points before a decision is made [11].

Mortality and morbidity risks of pediatric GA

GA is neither a risk-free technique or benign in any other way. Due to subjective interpretations, there is no agreement in the literature about the definition of anesthesia-related mortality; yet, the survival rates of children and newborns receiving GA have dramatically increased. This improvement can be attributed to the use of antibiotics, improved physiopathology knowledge, and developments in anaesthetic medications and support technology [15]. The hazards of paediatric anesthesia-related death have been quantified in earlier investigations. The majority of recorded deaths include newborns and babies, whereas young adults and teens are not at higher risk. Reducing the mortality risk in dental instances lowers the risk even more since these situations involve simpler procedures at older ages.

Keenan in 1994 [18] conducted an earlier review specifically examining GA in dental cases. He determined a mortality rate 1 per 162,000 cases over a five-year period. Interestingly, a ten-year review of medical records from regional hospitals from the American Hospital Association reported no deaths in 22,615 cases involving dental care under GA [16]. Morbidity risks in pediatric anesthesia can be divided into minor vs. major, with major morbidity being rare and both occurring mainly in the first year of life and severe associated co-morbidities [19].

Post-operative morbidity in dental settings is common; however, its severity is typically mild and limited to the first day. The most common complaints are an inability to eat, sleepiness, and pain. Less common are drowsiness, dental bleeding, vomiting, sore throat, psychological changes, nausea, coughing, and fever [20, 21].

The increasing use of GA in pediatric dentistry

The American Dental Association recognizes dental treatment under GA as a viable option to provide optimum care to children because of its low rates of post-operative complications, provided the indications for use are met [11]. Public acceptance of GA has also evolved in recent years, with an increase in preference for its use in parents when compared with negative behavioral management [22]. Therefore, the demand for GA in Western countries has been growing. In 2012, a North American online survey of the directors of dentist anesthesiologist and pediatric dentistry residencies revealed an 88% increase in requests for dentist anesthesiologist services by pediatric dentists in the past ten years [23]. Between 2004 and 2014 in New Zealand, a 65% increase of children receiving dental treatment under GA [24]. In 2015-16 in England, approximately 43,700 children aged 16 years and under were admitted to hospital with a primary diagnosis of dental caries [25]. In addition, the use of dental-related GA has increased in many other European countries, Asia, and the Middle East [26].

Does using general anaesthesia to treat ECC produce better outcomes? ECC treatment plans under GA may be divided into two primary categories: those that exclusively include extractions or those that include all possible therapies, including restorative, preventative, and exodontia. The decision is influenced by a variety of factors, such as the teeth's ability to be restored, the child's risk of developing caries, his or her capacity to maintain an acceptable level of hygiene, the parents' preferences and socioeconomic status, the likelihood of a follow-up, and the available resources.

For instance, in the UK, GA is primarily utilised for extractions [25]. GA often enables therapy to be carried out in an optimum setting; hence, expectations for an ideal result,

particularly in restorative therapies, are high. Several research have been published in the last ten years that show how effective GA-based ECC therapy techniques are. For this research, we used the index phrases "early childhood caries" and "dental general anaesthesia" to conduct a thorough search of the PubMed database from 2009 through 2019. After reviewing their abstracts, only pertinent research written in English were added. Papers were selected if they reported studies restricted to a healthy preschool child population and relevant to dental treatment of ECC under GA and/or the children's subsequent Oral Health Related Quality of Life (OHRQoL) post-GA. The initial search revealed 94 papers, of which 21 met the inclusion criteria. These studies are compiled in Table

Results

Impact of ECC rehabilitation under GA on OHRQoL

When evaluating the outcome of a treatment, both the clinical impact and incidence on quality of life should be considered. OHRQoL is an emerging multidimensional construct recognized by the World Health Organization as an important segment of the Global Oral Health Program (2003) [48]. OHRQoL assessments are particularly important in survey research to examine trends, highlight population needs, and measure treatment efficacy to improve care through potential policies and protocols. But most importantly, OHRQoL allows a shift from a traditional clinical approach to the integration of the patient as an active participant by considering the impact of oral disease and care on their daily emotional, social, and physical experiences [49]. Studies with short-term follow up periods have indicated a significant improvement in the OHRQoL of children. Interestingly, one long-term study highlighted that it has deteriorated over time after an immediate improvement. This indicates that GA is a positive addition to ECC management; however, it is important to discuss the limitations of these measures.

Short follow-up periods in most studies may be justified by participants' lack of contact after treatment; yet, long-term evaluation is required to assess the durability of outcomes because an early follow-up may not yet reflect the entire quality-of-life improvements from the treatment. Because most preschoolers lack the verbal and cognitive development needed to respond to the questions, surveys used to gauge patient satisfaction might be biassed or include inaccurate information. This indicates that the majority of replies rely on parental or other carer perspectives as a proxy. Depending on the family dynamics and personality attributes, this can result in a different viewpoint. In addition, high parental satisfaction does not always match the post-operative outcome. Treatment choices (restorative, exodontia, and pre-ventive) might also influence the scores. While these represent a positive overall effect, further studies are required to assess different treatment types and the application of age-appropriate scores.

Impact of ECC rehabilitation under GA on restorative outcomes and caries relapse

Most recent studies do not report different treatment choices, the restorative failure rate, or the caries relapse rate. These studies rely on parental satisfaction and overall quality of life as outcome measurements. Jang and Shen (2019) and Amin (2016) did report these factors and show similar findings to previous studies. As early as 1991, O'Sullivan *et al.* [50] reported that the use of stainless-steel crowns (SSCs) in the treatment of ECC under GA yielded better results than conventional restorations with amalgam and composite (3% vs. 29% failure rate). They reported a failure rate of 2% for vital pulpotomies.

In line with this, El Eheideb *et al.* [51] reported that SSCs were more successful (95.5%) when compared with amalgam and composite restorations (50%) and pulpotomies showed a 97.1% success rate. In anterior teeth, strip crowns had a similar success rate when compared with composite resin materials and sealants had an increased average retention rate (68.3%). Further, Tate concluded that SSCs showed the most reliable results and blamed the failure of composite restorations on follow up length [52]. Eidelman *et al.* [53] compared the quality of restorations performed in young children with ECC under GA to those treated under sedation. They concluded that the frequent use of SSCs in the GA group is motivated by the extensive destruction of teeth and a reduced possibility for the requirement of further retreatment. Similarly, the absence of movement from the child allows for the use of sensitive strip crowns that provide better results in the GA group. Therefore, only 59% of patients under GA required a follow up, which is compared with 74% of patients under sedation. Nonetheless, ECC is an aggressive and multifactorial disease with a high relapse rate and higher chance of developing caries in permanent dentition [21, 22, 41]. Therefore, many children with ECC that are treated under GA exhibit high caries relapse rates. Almeida *et al.* [54] reported a 79% caries recurrence rate in children who underwent ECC treatment under GA; 17% of these patients required a repeat GA intervention within two years.

Similar results were revealed by Kakaounaki *et al.* [55]: 8.9% of 484 children required a re-intervention under GA during a 6-year follow up period. Further, Berkowitz *et al.* [56] reported that over half the children in their study exhibited new smooth surface caries lesions after 6 months and most parents were unresponsive to later appointments. Similarly, Foster reported that half their patients had new caries within two years and this relapse was more likely when parents failed to attend follow up care [57]. Amin *et al.* (2010) reported a 22% relapse rate in patients attending a recall appointment within 1 year following surgery compared with a 51% relapse rate in the group attending their first recalls at 13–24 months post-surgery. Correspondingly, an increased relapse rate from 51% in the high attendance patients to 68% in patients with lower attendance rates was reported by El Batawi (2014). The aggressive dental approach of ECC under GA (extractions, pulp therapy, and SSCs) did not decrease caries relapse, which might indicate that this is better explained by a lack of follow up care and persistence of cariogenic habits post rehabilitation [58, 59].

Hence, GA could be a better alternative in some circumstances for children who have substantial ECC damage and who are recalcitrant; nonetheless, strong adherence to post-operative protocols is essential to prevent the loss of any beneficial rehabilitation outcomes. Unreported caries recurrence may be indicated by poor follow-up compliance or participant loss. This emphasises that the major source of knowledge on the significance of cleanliness and follow-up care should be the carer. A strategy that just addresses the clinical results of caries without addressing or removing the underlying risk factors for ECC will be unsuccessful. Therefore, the role of the pediatric dentist goes beyond the surgical intervention because they are required to provide appropriate guidance

and insist on regular follow up visits. Future research should focus on the tooth-based and patient-related factors of relapse. Procedure focused studies will have clinical significance in determining the preferred protocols for the restorations of specific teeth or surfaces and the success rate of each procedure. Taking into consideration patient related factors is important because it affects equally the choice and success of specific treatments.

Table 2: ECC dental rehabilitation under GA around the world

First author/ Year of publication	Methodology/Sample size	Results
Jiang 2019 [27]	Single-center prospective cohort study conducted from December 2016 to June 2017. 159 children aged 2–5 years. 6-month and then 1-year follow-up. 117 children at 6-month follow-up. 101 children at 1-year follow-up.	Higher success rates for SSCs, indirect pulp capping, pulpectomy and sealant at 6 and 12 months. Caries relapse of 18.8% children after 12 months. OHRQoL immediately improved but deteriorated over time.
Ferrazzano 2019 [28]	Systematic review: Data analysis at baseline and one year follow up. 100 children aged 3–5 years.	OHRQoL improved one year after a complete treatment under GA.
Jiang 2019 [29]	Single-center prospective cohort study. 190 pre-school children. 1-month follow up. 180 children at follow up.	Dental treatment under GA improved the OHRQoL of Chinese preschool children.
Grant 2019 [30]	Prospective cohort study with a minimum 3-month follows up, maximum 12-month follow up. 150 Canadian pre-school children with severe ECC. 103 children at follow up.	Improvements in OHRQoL following GA.
Farsi 2018 [31]	Prospective study. 133 children ≤6 years of age. 1-month follow up.	Improvements in OHRQoL following GA.
Collado 2017 [32]	Prospective comparative study. 25 ECC preschool children aged 2–6 years undergoing GA, compared with 16 caries-free children. 1- and 3-month follow-up.	Oro-facial functions and quality of life, altered by ECC, could be restored through a conservative treatment approach under DGA.
Rane 2017 [33]	Observational prospective comparative study. 50 parents of children aged 2–6 years old with ECC divided into 2 groups: 25 parents of children treated under GA, 25 parents of children treated under LA. 1-month follow up.	Improvement in OHRQoL within one month, regardless of GA or LA.
Chao 2017 [34]	Retrospective study of data collection. 659 pediatric patients treated for ECC under GA from 2013–2014. One month follow up.	Children OHRQoL improved significantly. 82.8% of families reported a high degree of satisfaction.
Amin 2016 [35]	Retrospective cohort study. 818 ECC children, ≤72 months at the time of treatment. 3-year follow up.	Amalgam restorations and SSCs showed longer survival rates than composite restorations. Higher survival rate of pulpectomies compared to indirect pulp capping and pulpotomies. 32.9% required retreatment over the 3 year follow up.
Wong 2016 [36]	Data collection. 221 preschool children who underwent emergency extractions under GA over a 12-month period. 2-week follow up. 126 children at follow up.	Emergency dental extraction under GA significantly improved the OHRQoL of preschool children who presented to the emergency department with the consequences of untreated dental caries.
De Souza 2016 [37]	Cohort study. 78 parents of 2–6 year old children with ECC undergoing GA. A minimum of 1-month follow-up. 72 parents follow-up.	Substantial improvements in parents' ratings of their children's OHRQoL.
Yawary 2016 [38]	Data collection, parents' questionnaire. 70 parents of preschool children under age 6 undergoing oral rehabilitation under GA. Two weeks and then 3-month follow-up. 39 parents at follow up.	OHRQoL of children less than 6 years of age was improved after comprehensive oral rehabilitation under GA, improvement sustained over a three month period.
Amin 2015 [39]	Single center retrospective cohort study. 278 children <6 years of age at the time of GA. 36-month follow up period over 5 recall visits. 45.3% children returned for all recall visits.	Caries relapse rate of 21.6%. ASA-2 children and those with less than full primary dentition during GA were twice as likely to experience caries relapse.
El Batawi 2014 [40]	Prospective study of questionnaire data. 352 pediatric patients undergoing GA for ECC. 2-year follow up.	58.8% caries recurrence. 99.14% parent satisfaction rate.
EzEldeen 2014 [41]	Long term follow-up study. 98 children treated for ECC under GA.	Individuals with a history of ECC remained at a high risk of caries in the permanent dentition.

	1- and 12-year follow-up period. 48% attended the 12-year follow-up.	
Jankauskiene 2014 [42]	Prospective clinical follow up study during 2010–2012 of patients <6 years old. 140 base patients. 1-month follow up. 122 follow up patients.	Dental GA treatment results in significant improvement of the children's OHRQoL.
Cantekin 2014 [43]	Data collection. Clinical sample of 311 caregivers and their 4–6 years of age children who received GA. 1- to 3-week follow up.	Quality of life improved. Number of extractions associated with increased levels of fear.
El Batawi 2014 [44]	Retrospective longitudinal study. Medical records of 431 ECC children who underwent oral rehabilitation under GA during 2011.	18% failed to attend any post-operative visit. 26% did not comply with the post-operative preventive plan. 67.8% caries recurrence rate in the non-compliant group vs. 50% in the most compliant. Highest frequency of repeat GA in the non-compliant group (10%).
Peerbhay 2012 [45]	Retrospective descriptive study between 2005 and 2007. Database of 16 732 pre-school patients treated under Dental General Anaesthesia over a three year period.	Of 58,255 procedures, 99,94% were extractions. The lack of preventive measures could possibly result in a need for retreatment under DGA.
Amin 2010 [46]	Retrospective study. Review of dental charts for 269 patients <6 years of age between 2005 and 2007.	Patients who had a previous dental GA were less likely to relapse in the short term (1–6 months after GA), but more likely to relapse in the longer term (19–24 months), as compared with those who had not had another GA. A comprehensive and frequent preventive approach is required.
Klaassen 2009 [47]	Randomized controlled trial design. 104 children (mean age, 4.08 y). 1-month follow up.	OHRQoL improved after treatment under GA.

Conclusion

For patients with ECC who need substantial dental treatment, the goal of employing GA is to restore good oral health in a single visit and eliminate any anxiety associated with several dental chair sessions. It should be seen as a behavioral management method rather than a magic cure-all strategy, although its effectiveness is strongly dependent on periodic follow-up visits. In order to maintain positive outcomes and avoid any recurrence, carer education and motivation are crucial. Attending follow-up appointments, routinely reviewing and/or changing dietary programmers, and practicing good cleanliness are all part of this.

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