



Pulse Oximetry in Paediatric Dentistry

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Abstract

Pulse oximetry is a technique used to measure the levels of blood oxygen saturation. Because this technique is regarded as non-invasive, easy to apply, and accurate technology, the number of possible applications in general dentistry practice has been gradually increasing. The aim of the present study was to summarise the contemporary research literature concerning the use of pulse oximetry in paediatric dentistry. We made a critical evaluation of the clinical applications of pulse oximetry and the advantages and disadvantages of this technique. Knowledge of innovative methods and techniques for treatment and diagnostics by paediatric dentists is a valuable advantage in dealing with the functional problems in attending dental patients. The expository analysis allows reviewing the succession of this diagnostic approach.

Keywords

dental anxiety assessment, oxygen saturation, pulse oximetry, pulp vitality test

INTRODUCTION

Pulse oximetry is a technique used in measuring the levels of blood oxygen saturation. It is considered as a non-invasive, easily applied, and accurate method.^[1] The mechanism of action of this technique allows evaluation of the fraction of oxygen-saturated haemoglobin relative to total haemoglobin in the arterial blood. The pulse oximetry system uses light of two different wavelengths – red light (660 nm) and infrared light (850 nm).^[1,2] Pulse oximetry is based on the different colours of oxygenated and deoxygenated haemoglobin and its different absorbent potential for the two light streams used.^[3] On the one side of the investigated vascular zone, there are two photodiodes – one of them emits red light and the other – infrared light.^[3,4] Part of the light is absorbed when it passes through the plasma by the haemoglobin. The quantity of light trans-

mitted through a selected vascular bed is registered by a photodetector located on the opposite side of the diodes. The oxygenated and deoxygenated haemoglobin have different absorbent spectra.^[3] The measurement is calculated by a microprocessor and displayed on the screen/display of a device, called a pulse oximeter. Some models of pulse oximeter include notifications as sound alarms when changes in the pulse rate and levels of oxygen saturation occur. The clip sensor of the device is usually placed on the finger or earlobe in children.^[1-4] In addition to the function of conventional pulse oximeters to diagnose hypoxia, the latest versions evaluate methemoglobin and carboxyhemoglobin levels, total haemoglobin, oxygen levels above 100% saturation.

Oxygen saturation represents the percentage of hemoglobin saturated with oxygen in arterial blood and is a 'mirror' of the blood supply to tissues.^[5] Variability in oxygen saturation is a sign of compromise of the cardiorespirato-

ry system.^[5] Pulse oximetry allows immediate detection of tissue hypoxia, control and monitoring the effect of the treatment decisions.^[6] During dental treatment under general anesthesia or sedation, an awareness of this parameter is of great importance for the paediatric dentists and the treatment team to manage the treatment and be prepared for complications. The other measured parameter, the pulse rate, is an indicator for the function of the autonomic nervous system which reflects negative emotions and shows if one is anxious or relaxed.^[7] Therefore, the increase of the pulse rate during dental procedures demonstrates high dental anxiety levels and vice versa - reference ranges for heart rates are associated with non-anxious dental patients.^[8]

AIM

The aim of this article was to summarise the contemporary research literature concerning the use of pulse oximetry in paediatric dentistry. We made a critical evaluation of the clinical applications of pulse oximetry and the advantages and disadvantages of this technique. The expository analysis allows reviewing the succession of this diagnostic approach.

There are several clinical applications of pulse oximetry in paediatric dentistry for diagnostics and monitoring (Table 1).

Oxygen saturation monitoring during dental treatment under general anesthesia or sedation

The first most popular and significant application of this technique is the monitoring of two physiological parameters – the pulse rate and oxygen saturation, during dental treatment of paediatric patients under general anesthesia and sedation, most commonly nitrous oxide sedation. In accordance with the American Academy of Pediatric Dentistry (AAPD) Guideline on the use of nitrous oxide for pediatric dental patients (2018) and Practice Guidelines for Moderate Procedural Sedation and Analgesia (2018) by the American Society of Anesthesiologists, continuous moni-

toring of the patient by pulse oximetry along with sound alarms during sedation is recommended.^[9,10] In contrast, European Academy of Paediatric Dentistry (EAPD) considers that pulse oximetry is not required for conscious sedation with nitrous oxide but is preferable in benzodiazepine sedation. They report a significant number of false positive alarms and an increased anxiety in paediatric patients to the placement of the pulse oximeter.^[11] During the sedation, administration and immediate recovery phase, the continuous pulse oximeter monitoring of oxyhemoglobin saturation must be recorded at a minimum of 15-minute intervals.^[12]

The American Dental Association (ADA) recommends baseline vital signs such as pulse rate, blood pressure, and oxygen saturation to be obtained and recorded by pulse oximeter during dental treatment under general anesthesia.^[13] Oxygen saturation by pulse oximetry may be clinically useful and should be considered.^[13]

Oxygen saturation and pulse rate monitoring during local anesthesia

Due to the low cost and easy use of this technology, Gandy reported it as a standard of patient care and a useful method in the dental office during local anesthesia for monitoring of hypoxia.^[14] In a systematic review of local anesthetic-related methemoglobinemia, Guay pointed out that the use of a pulse oximeter was required when infants had undergone local anesthesia, especially in children under 3 years old.^[15] Usually, it is associated with compromised patients or children with special needs. In 2019, Lu et al. compared the response of pulse oximetry and regional cerebral oxygen saturation to hypoxia in preschool children and found that pulse oximetry allowed rapid identification of hypoxic state.^[16] The authors considered this technique as an alternative to intermittent arterial blood sampling owing to its non-invasive and consecutive mechanism of monitoring.

The aforementioned articles reported the required use of pulse oximetry during dental treatment of paediatric patients when sedation and different types of anesthesia must have been used.^[9-16]

Table 1. Clinical application of pulse oximetry in paediatric dentistry

| | Parameters of patient monitoring | Application/dental procedure | Period/moments of monitoring |
|---|----------------------------------------------|-------------------------------------------|------------------------------------------------------|
| 1 | Oxygen saturation (SpO_2) | Dental treatment under general anesthesia | continuous |
| 2 | Oxygen saturation (SpO_2) | Local anesthesia | continuous |
| 3 | Oxygen saturation (SpO_2) | Dental treatment under sedation | continuous |
| 4 | Pulse rate | Assessment of dental anxiety | continuous/different moments during the dental visit |
| 5 | Oxygen saturation (SpO_2) of pulp tissue | Pulp vitality test | 10-to-30-minute period |

Objective assessment of dental anxiety

Another use of pulse oximetry in paediatric dentistry is as an objective method of assessing the patients' dental anxiety by measuring their pulse rate at different time points of dental visit: 1. patient staying in the waiting room; 2. when the patient is sitting on the dental chair; 3. during oral examination; 4. during the dental treatment; and 5. at the end of the dental procedure.

Finger pulse oximeter has been accepted as a reliable device for direct measurement of pulse rate in dental settings which is considered as a physiological indicator of dental anxiety.^[17-19] The increase in the pulse rate corresponds to high levels of dental anxiety and stress during the dental visit.^[18] Yadav et al. found it an objective, non-invasive technique for the evaluation of physiological changes caused by the subjective nature of anxiety.^[18] The results of numerous studies are in line with their findings and using a finger pulse oximeter remains the most acceptable method to measure a patient's heart rate.^[17,20,21] The data were recorded and analysed by a specially developed digital processing and graphic visualization software. Heart rate was chosen for analysis because it is the simplest biological parameter to measure and because an increase in heart rate is the most common physiologic indicator of anxiety and fear.^[22] It has been shown that this parameter is more in line with the anxiety experienced in dental visits than the other physiological parameters.^[23,24] There was an investigation that found a correlation indicating that self-report anxiety degree as a subjective method for assessment is comparable to heart rate as a physiological stress indicator.^[25] Despite these findings, for reliable assessment of dental anxiety in paediatric dental patients, researchers usually used a combination of subjective (a facial or numeric scale) and objective method (a physiological indicator).^[19,26]

Pulp vitality testing

In recent years, direct implementation of the mechanism of action of pulse oximetry in dentistry has been achieved. Several studies reported the use of this technique to monitor arterial blood oxygen saturation of dental pulp.^[1,2,4,27-30] Kakino et al. found that the function and vitality of dental pulp depend more on the microcirculatory system of the tissue rather than its sensory nerve response.^[31] Due to the false negative results when immature traumatized teeth are inspected and the subjective response of the patient, pulp tests used to determine neural response are not suitable to be used in paediatric dentistry.^[1,3,31] Thus, the innovative methods for pulp vitality testing in attending paediatric dental patients are based on the state of the blood supply of pulp tissue. Despite the reliability and accuracy of the laser Doppler flowmetry, the latest studies emphasized several limitations of the obtained results.^[32-34] Akpınar et al., Polat et al., and Gopikrishna et al. reported false positive results due to the interference of laser transmission in case of discolouration of the crown of the tooth

or contamination of the backscattered light from the periodontal tissues.^[32-34]

In searching for a non-invasive, more reliable and objective method, several researchers found that pulse oximetry is a successful technique in the monitoring of arterial blood supply of dental pulp.^[1,2,4,27-30] The results obtained by a significant number of studies showed that this method could be successfully used in everyday dental practice as a reliable and accurate vitality test.^[27-34] However, until 2021 no devices have been particularly developed and adjusted for dental use – modified versions of rubber dam clamps, different custom-made stainless steel or plastic adapters to the finger or earlobe sensor were reported.^[2,4,28,29] Summarising the articles evaluating arterial oxygen saturation of dental pulp in the field of pediatric dentistry, only one research conducted by Sharma et al. was identified. The authors tested a customized pulse oximeter for pulp vitality diagnostics of primary and permanent teeth and found it a valuable adjunct to diagnosing.^[35] In 2021, Grabliauskienė et al. described a new universal pulse oximeter probe holder developed at the Lithuanian University of Health and Science, Kaunas, Lithuania.^[36] Using software for 3D CAD (Computer-aided design) and a 3D printer, a sample of the holder was designed and made of thermoplastic polyester. The authors demonstrated perfect adaptation of the holder to the specific characteristics associated with the tooth type and group, anatomy, shape, size and parallel maintenance of the two photodiodes and photodetector to ensure precise measurement. The results of the study over 128 healthy asymptomatic teeth with complete root development confirmed the opportunity for the potential use of the newly developed tool for pulp test vitality in adults.^[36] However, further investigations should be conducted to identify the accuracy and reliability of the universal pulse oximeter probe holder in immature teeth.

CONCLUSIONS

Paediatric dentists are expected to be aware of the innovative methods and techniques for treatment and diagnostics of attending paediatric dental patients. The number of potential possibilities for use of the pulse oximeter in general dental practice has been gradually increased. Along with the mandatory monitoring of oxygen saturation during dental treatment under general anesthesia or sedation, this technique is useful for the objective assessment of the patient's dental anxiety as well as for the accurate and non-invasive pulp vitality test. Therefore, it is considered a promising and reliable 'atraumatic' opportunity for chair-side screening during dental treatment of children.

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Пульсоксиметрия в детской стоматологии

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Резюме

Пульсоксиметрия – это метод, используемый для измерения уровня насыщения крови кислородом. Поскольку этот метод считается неинвазивным, простым в применении и точным, количество возможных применений в общей стоматологической практике постепенно увеличивается. Цель настоящего исследования состояла в том, чтобы обобщить результаты обзора современной исследовательской литературы по использованию пульсоксиметрии в детской стоматологии. Мы критически оценили клиническое применение пульсоксиметрии, а также преимущества и недостатки этой методики.

Знание инновационных методов и методик лечения и диагностики детскими стоматологами является ценным преимуществом при решении функциональных проблем у стоматологических больных. Данный анализ позволяет рассмотреть преемственность этого диагностического подхода.

Ключевые слова

оценка стоматологической тревожности, сатурация кислорода, пульсоксиметрия, тест жизнеспособности пульпы
