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Local anesthesia in dentistry: Revisited

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Abstract
Pain and its successful management have been one of the cornerstones of Dentistry worldwide since time immemorial. Most of the researches are focused on improvement in the area of anesthetic agents, delivery devices and technique involved. Newer technologies have been developed that can assist the dentist in providing enhanced pain relief with reduced injection pain and fewer adverse effects. The preset review of literature focus to discuss about composition, safety dose, adverse reaction of local anesthetic agent and its recent modifications.

Keywords: local anesthesia, local anesthetic agent, pain control

Introduction

Pain and its successful management have been one of the cornerstones of Dentistry worldwide since time immemorial [1]. The successful use of local anesthetic solutions and their diligent administration have helped patients overcome their fears and displeasure towards dentistry. The injection of local anesthetic is perhaps the greatest source of patient fear and inability to obtain adequate pain control with minimal discomfort remains a significant concern of dental practitioners. The achievement of good local anesthesia requires knowledge of the agents being used, the neuroanatomy involved, best techniques and devices available. The agents and anesthetic delivery equipments Available today provide the practitioner an array of options to effectively manage the pain associated with dental procedures [2]. The preset review of literature focus to discuss about composition, safety dose, adverse reaction of local anesthetic agent and its recent modifications.

Table 1: Classification of Local Anesthetics [3]

Esters of Benzoic acid	Amides	Esters of para amino benzoic acid	Quinolone
Butacaine Cocaine Benzocaine Hexylcaine Piperocaine Tetracaine	Articaine Bupivacaine Dibucaine Etidocaine Lidocaine Mepicvacaine Prilocaine Ropivacaine	Chloroprocaine Procaine Propoxycaine	Centbucridine

Table 2: Constituents of Local Anesthetics [4]

Local anesthetic agent	Vasoconstrictor	Reducing Agents (Antioxidant)	Preservatives
It interrupts the propagated nerve impulse, preventing it from reaching the brain.	It is to increase the safety and duration and depth of action of local anesthetic	To prevent the oxidation of the vasopressor by oxygen which might be trapped in the cartridge during manufacture or diffuse through the semipermeable diaphragm after filling.	Bacteriostatic agent.
Vehicle	The anesthetic agent and its additives are dissolved in sodium chloride. This isotonic vehicle minimizes discomfort during injection.		
Distilled Water	Distilled water is added as the diluent to provide the volume of the solution in the cartridge.		

Selection of Local Anesthetic Agent: According to AAPD guidelines, selection of local anesthetic solution is based upon: [5]

The patient's medical history and mental developmental status.
The anticipated duration of the procedure.
The need for haemorrhage control.
The planned administration of other agents (sedative agents

and general anesthesia)
The practitioner's knowledge of the anesthetic agent

Safety dose of Local Anesthetic Agent

The dosage of the local anesthetic depends on the physical status of patient, area to be anesthetized, vascularity of oral tissues, and the technique of administration. It is difficult to recommend a maximum dose for children because dose varies with functions of age and weight. For pediatric patients less than 10 years who have lean body mass and normal body development, the maximum dose may be determined by application of one of the standard formulas (Clarks rule). In any case, the maximum dose should not exceed 7 mg/kg body weight for lidocaine with epinephrine and 4.4 mg/kg for plain adrenaline. Toxicity occurs primarily in the cardiovascular and central nervous system; this toxic reaction could stimulate or depress the central nervous system [5]. The commonly used dental cartridge contains 1.8 mL of (2% lignocaine) local anesthetic solution. In this cartridge, the concentration of epinephrine varies in concentration from 1:200,000 (5 µg/mL), 1:100,000 (10 µg/mL) to as high as 1:50,000 (20 µg/mL). The maximum dose of LA with epinephrine is 7 mg/kg and concentration of LA used is 2% (20 mg/mL), thus the maximum volume of LA, which can be safely used, is 0.35 mL/kg. In an average 60 kg adult, the maximum volume of LA which can be used is 21 mL (0.35 mL/kg × 60 kg) or 11 cartridges. The 21 mL volume of LA (1:200,000) preparation will deliver 105 µg of epinephrine, 21 mL volume of LA (1:100,000) preparation will deliver 210 µg of epinephrine and (1:50,000) preparation of LA will deliver 420 µg of epinephrine, whereas maximum recommended dose of epinephrine per appointment in a dental patient is only 40 µg. As higher dosage can produce systemic vasoconstriction leading to myocardial ischemia in high-risk cardiac patients, undergoing dental procedure. Thus, for cardiac patients undergoing a dental procedure, the dose of LA which can be safely given with 1:50,000 epinephrine is 2 mL (40 µg/20 µg mL^{-1}) with 1:100,000 is 4 mL (40 µg/10 µg mL^{-1}) and with 1: 200,000 is 8 mL (40 µg/5 µg mL^{-1}) [6]. It has to be taken into consideration that safe upper limit of LA with epinephrine is 7 mg/kg (up to 21 mL for 60 kg body weight) but simultaneously, it will deliver very high concentration of epinephrine, which can cause detrimental effects; so, safe upper limit of LA with epinephrine to be used in cardiac patients is no more than 8 mL (4 cartridges) of 2% lignocaine with 1:200,000 epinephrine; 4 mL (2 cartridges) of 2% lidocaine with 1:100,000 epinephrine and only 2 mL (1 cartridge) of 2% lignocaine with 1:50,000 epinephrine should be used for any dental procedure for older adults with cardiovascular disease.For patients with stabilized cardiovascular diseases, routine dental treatment may usually be delivered. However, patients with unstable cardiac condition dental care should be deferred until their medical conditions have been stabilized under the care of their physicians [6].

Table 3: Adverse reactions of commonly used Local Anaesthetics

Psychogenic	Allergic (potential allergens	Toxic effects
Syncope (most common) Hyperventilation Nausea, vomiting Alterations in heart rate or blood pressure Mimicking of an allergic reaction	Esters (true amide allergy is very rare) Metabisulfite (present with epinephrine and with levonordefrin) Methylparaben (no longer added to dental cartridges)	Primarily neurologic signs may initially manifest as sedation, light-headedness, slurred speech, mood alteration, diplopia, sensory disturbances, disorientation, and muscle twitching. Higher blood levels may result in tremors, respiratory depression, tonic–clonic seizures. If severe, may result in coma, respiratory arrest, cardiovascular collapse Methemoglobinemia Associated with prilocaine, articaine, benzocaine Paresthesia Apparently more common with articaine and prilocaine

Recent advancement in Local Anesthetic Solution

Centbucridine: It is a local anesthetic molecule synthesized at the Centre for Drug Research of India at Lucknow, India in the year 1983. It is a quinolone derivative with local anesthetic action. It has intrinsic vasoconstricting and anti-histaminic properties. Centbucridine in a concentration of 0.5% can be used effectively for infiltration, nerve blocks and spinal anesthesia with an anesthetic potency 4-5 times greater than that of 2% lignocaine [7]. Centbucridine has been tested successfully as a topical anesthetic in ophthalmic surgeries. Its topical anesthetic action is concentration dependent. It also demonstrates a longer duration of action and analgesic properties. This novel molecule has been extensively used in ophthalmology and other medical specialties, however, strangely the dental profession has failed to capitalize on its strengths and also validate its use in the management of pain in dental procedures [8].

Articaine: it belongs to the Amide group of local anaesthetics. It consists of a thiophene ring instead of a benzene ring and an ester group that is metabolized by esterases in the tissues. Elimination of Articaine is exponential with a half-life of about 20 minutes. Metabolism is mainly in the liver and plasma by unspecified plasma esterases [1]. Study conducted by Khoury F et al. compared four different local anesthetic solutions (2% lignocaine with 1:1,00,000 epinephrine, 4% Articaine with 1:1,00,000 epinephrine, 4% Articaine with 1:2,00,000 epinephrine and 3% Prilocaine with Felypressin) revealed that 4% Articaine with 1:1,00,000 epinephrine was the most effective solution [9].

Recent Advancement in Delivery Devices

Transcutaneous Electrical Nerve Stimulation (TENS): It is an electroanalgesia and used in simple restorations and periodontal procedures. Two mechanisms have been explained. One is that TENS stimulate the release of the body's endogenous opiates. The other is based on Melzack and Wall's gate control theory [10] Choudhari SR et al. (2017) compared the efficacy of Transcutaneous electrical nerve stimulation (TENS) and 20% benzocaine gel prior to inferior alveolar nerve block (IANB) injections in alleviating pain in children of 8–12 years of age. Author found application of TENS was more comfortable and significantly reduced pain. TENS is a safe, reliable, and

practical alternative to be used in pediatric dentistry [11].

Computer-Controlled Local Anesthetic Delivery System: Many devices have been introduced that can inject local anesthetic into the tissues at a set speed. Collectively, these "painless anesthetic devices", are termed "computer-controlled local anesthetic delivery" (CCLAD) devices. CCLAD also collectively refers to devices that not only slow and maintain the injection speed, but also maintain a constant speed while taking into account the anatomical characteristics of the tissues being injected. The most widely known devices of this type include the Wand® (Milestone Scientific, Livingstone, NJ), Comfort Control Syringe (CCS; Dentsply, USA), QuickSleeper (Dental HiTec, France), and iCT (Dentium, Seoul, Korea) [12]. TD Yogesh Kumar et al. (2015) found Injections with CCLAD produced significantly lesser pain response when compared to cartridge syringe injections.

Vibraject: A vibrating dental local anesthesia attachment has been introduced in recent years. This device was developed on the basis of the gate-control theory which states that pain transmission through A- delta and C nociceptive fibers is depressed at the secondary neuronal cell bodies in the dorsal horn if the nerve impulses evoked by tactile sensation are simultaneously transmitted through A delta fibers. It is therefore supposed that vibrating a needle with Vibraject can result in a reduction in injection pain. Yoshikawa et al. (2003) reported that injection pain did not decrease when Vibraject was applied with a conventional cartridge type dental syringe with a 30 gauge needle [13].

Dentipatch: A patch that contains 10-20% lidocaine is placed on the dried mucosa for 15 minutes. Shehab LA et al. (2015) effectiveness of the lidocaine Denti-patch ® system versus the lidocaine topical anesthetic gel in children concerning pain reaction during injection and found Denti-patch ® system can significantly reduce the needle injection pain more than the gel [14].

Jet injection: It was developed to achieve local anesthesia for dental procedures without the use of a needle. This is accomplished by delivering the anesthetic solution under high compressive forces. A number of uncontrolled studies of needleless devices have examined adult and child patients, typically focusing on the anesthetic properties of the device used. In these studies, the percentage of patients who obtained sufficient anesthesia with the devices ranged from about 50 to about 90%. Traditional infiltration was more effective, acceptable, and preferred, compared with the needleless injection [14, 15].

Ultra Safety Plus XL syringe: The Ultra Safety Plus XL syringe (Septodont, Lancaster, PA, USA) has a sterile disposable protective shield that is fitted with a dental needle into which anesthetic carpules are placed. The plunger assembly is reusable and auto clavable. The Ultra Safety Plus XL syringe provides protection from the needle because the needle is covered both before and after injection, and the needle does not have to be disassembled prior to disposal, which further protects the worker who is cleaning the dental tray. Providers who used this type of syringe reported that there was more time required for changing anesthetic carpules [17].

Iontophoresis: This technique first introduced in 1993 is a suitable alternative for application of drug in achieving surface anesthesia. It is a painless modality of administrating anesthesia. Initial reports have shown an encouraging response from patients; however, further research is warranted. In iontophoresis, a small electric current forces molecules into the mucosa. An electrode patch containing the drug is placed on the skin and this acts as the working electrode. This can be either positive or negative, depending on the characteristics of the drug. Another electrode is placed elsewhere to complete the electrical circuit and a small current of 0.5 mA/cm2 is applied to deliver the drug through the skin. Iontophoresis thus uses an electrode of same polarity as the charge on the drug to drive ionic (charged) drugs into the body by electrostatic repulsion [18].

Buzzy System: Buzzy is a hand-held device that naturally and quickly minimizes sharp pain from needle sticks like IV starts, blood draws, finger pricks and immunizations, through a combination of vibration, ice and distraction methods. Suohu T et al. (2020) conducted a study to evaluate the pain perception and comfort of patient during local anesthesia (LA) delivery using Buzzy system and conventional syringe and found that the external cold and vibration via Buzzy® can reduce pain and anxiety during local anesthetic delivery for various dental procedures [19].

Dental Vibe: Another system that uses vibration diversion based on the pain gate theory is recently introduced Dental Vibe (BING Innovations LLC, Crystal Lake, IL, USA). It is a cordless, rechargeable, hand held device that delivers soothing, pulsed, percussive micro oscillations to the site where an injection is being administered. Its U shaped vibrating tip attached to a microprocessor controlled Vibra Pulse motor gently stimulates the sensory receptors at the injection site, effectively closing the neural pain gate, blocking the painful sensation of injections. It also lights the injection area and has an attachment to retract the lip or cheek [2].

Conclusion

Local anesthetics have made a great advancement in dentistry and have changed patient's perspectives of dental procedures to a great extent. Despite the recent innovations, the injection remains the method of choice in providing local anesthesia. There is a need in the current evidence-based era of dental practice for us to constantly update, evaluate and incorporate newer drugs and techniques into daily practice to provide our patients the best of care at all times.

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