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Recent Advances in Local Anesthesia Techniques and Agents

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ABSTRACT

Recent advances in local anesthesia techniques and agents represent significant developments in pain management during dental and surgical procedures. Innovations such as enhanced delivery methods, novel anesthetic agents, and improved pain control strategies have optimized patient comfort and outcomes. This paper explores the latest techniques, including the use of computer-controlled local anesthesia delivery systems, the introduction of new anesthetic agents with fewer side effects, and the application of regional anesthesia techniques that provide longer-lasting effects. Understanding these advancements is essential for practitioners to deliver safe and effective care, ultimately enhancing the patient experience and improving procedural success.

Keywords: *Pain, Local Anesthesia, Local Anesthetics Agent*

1. INTRODUCTION

Local anesthesia is pivotal in modern dentistry and surgery, providing effective pain relief while allowing patients to remain conscious. Recent technological and pharmacological advances have refined local anesthesia techniques, resulting in improved patient outcomes and experiences. The emergence of computer-assisted anesthesia delivery systems provides greater precision, reducing the discomfort often associated with traditional techniques. Additionally, the development of new anesthetic agents, such as liposomal bupivacaine, offers extended analgesia with a reduced risk of toxicity.[1,2] This paper examines these recent advancements in local anesthesia, their practical applications, and the importance of integrating these innovations into clinical practice to enhance patient care. **(Table 1)**

Table 1: Recent Advances in Local Anesthetics Agent and Technique

Agents/ Techniques	Details
Cetacaine topical anesthetic liquid	Dispensed into periodontal pocket; up to 60 minutes of topical anesthesia achieved
Oraqix subgingival anesthetic gel	Inserted into gingival sulcus; anesthesia lasts for 20 minutes
DentiPatch® system	Lidocaine in DentiPatch diffuses into mucosa
Centbucridine	Natural vasoconstrictive effect
CCLAD	Computerized device controls the injection speed
Jet injector	Anesthetic solution delivered using high pressure and velocity penetrate through oral mucosa
Buzzy® device	Based on Gate control theory of pain and distraction
Cryoanesthesia	Based on Gate control theory of pain
EDA	Analgesic effect based on Gate control theory of pain and endogenous opioid theory

Topical Anesthetic Agents: Topical anesthetic agents work by reversibly blocking nerve conduction in the free nerve endings of the dermis or mucosa at the site of administration, thereby reducing the painful sensation associated with needle penetration. To effectively anesthetize surface tissues, a contact time of at least one minute on dried mucosa is typically necessary, achieving depth anesthesia of up to 23 mm.[1]

Hurripak Periodontal Anesthetic Kit: One specific product, the HurriPAK periodontal anesthetic kit, consists of a 3 ml plastic syringe filled with a 20% benzocaine solution, delivered deep into the gingival sulcus through disposable plastic tips. This anesthetic has an onset of action of around 30 seconds and lasts approximately 15 minutes. For lengthy surgical procedures in adults, additional re-administration or the use of infiltration or periodontal ligament anesthesia may be required.[1]

Oraqix subgingival anesthetic gel: Oraqix is a non-injectable subgingival anesthetic gel that contains 2.5% lidocaine and 2.5% prilocaine. It is applied directly into the gingival sulcus to provide anesthesia for deep scaling and root planing. Additionally, Oraqix is effective in alleviating discomfort or pain that may occur after the placement of orthodontic elastomeric separators. Studies have reported a significant reduction in needle prick pain in the palatal mucosa after applying Oraqix. However, there is currently no available information regarding its pharmacokinetics and safe dosage for children under 18 years of age.[2]

Clove-Papaya-Based Topical Anesthetic Gel (Eco Pain Care): Another topical anesthetic option is the clove-papaya-based gel (Eco Pain Care), which comprises clove oil (known for its analgesic properties), chloramine (acting as a gelling agent), and papaya extract (serving as the vehicle). The clove oil works by activating calcium and chloride channels in ganglion cells, leading to its analgesic effects. Research conducted by Anantharaj et al. found no statistically significant differences in the topical anesthetic efficacy of the clove-papaya-based gel compared to other anesthetic agents.[3]

DentiPatch® System: A transmucosal delivery system is designed to release lidocaine, providing pre-injection numbness. Most children reported experiencing less pain during injections and preferred the patch over the traditional benzocaine gel. This mucoadhesive patch, which contains 46.1 mg of 20% lidocaine, is applied for five minutes. In children around 7 years of age, the mean peak plasma concentration reached 82 ng/mL, which is significantly below toxic levels but approximately 45 times higher than concentrations seen in adult patients. Therefore, this dosage should be factored into the calculation for the maximum allowable lidocaine dose in pediatric patients.[4]

Research by Shehab et al. indicated that the DentiPatch® system was more effective than lidocaine gel in reducing pain during injections in children, which subsequently improved their behavior during future dental visits.

Recent Advances in Local Anesthetic Drugs: Recent advancements in local anesthetic drugs include Articaine and Centbucridine, both of which have demonstrated effectiveness equal to or potentially exceeding that of Lignocaine.[5]

Articaine: is an amide-type local anesthetic that features an ester group, allowing for processing by tissue esterases, and has a thiophene ring instead of a benzene ring. It has an exponential half-life and is eliminated over a longer duration. The metabolism of Articaine primarily involves unidentified plasma esterases occurring in the liver and plasma.[5]

Comparison of Articaine and Lignocaine:

1. Articaine has a faster onset of action.

2. Its anesthetic effects last longer.

3. Articaine boasts a higher success rate in procedures.

4. It is 1.5 times more potent than Lignocaine.

5. Articaine presents a lower risk of systemic toxicity.

6. Overall, Articaine is regarded as a safe medication.

Centbucridine: Centbucridine is a local anesthetic molecule developed in 1983 at the Centre for Drug Research in Lucknow, India. This quinolone derivative exhibits both anti-histaminic and vasoconstricting properties. With an anesthetic potency 4-5 times greater than that of 2% Lignocaine, Centbucridine can be effectively used for infiltration, nerve blocks, and spinal anesthesia at a concentration of 0.5%.

Despite its potential advantages, clinicians have not fully utilized its benefits or validated its application for pain management in dental procedures. However, Centbucridine has been widely adopted in ophthalmology and other medical fields. According to Gune and Katre, Centbucridine is comparable to Lignocaine and can serve as an alternative for patients aged 12 to 14 who have hypersensitivity, as well as for those with cardiac and thyroid conditions where vasoconstrictors are contraindicated.[5,6]

2. LOCAL ANESTHESIA DELIVERY DEVICES

Computer-Controlled Local Anesthesia Delivery (CCLAD): Computer technology enables the delivery of local anesthetic solutions at fixed flow rates, irrespective of variations in tissue resistance. The Wand's syringe is housed within the main unit, while devices like the Quicksleeper and Comfort Control Syringe consist of a separate base unit and syringe. The Wand is a computerized-controlled Single Tooth Anesthesia (STA) system designed for intraligamentary injection, targeting the specific tooth requiring treatment. This STA technique minimizes anticipatory anxiety and physical discomfort, avoids anesthesia of the perioral tissue, and allows for the administration of a controlled lower dose of anesthetic liquid.[7]

Research by Garret-Bernardin et al. found that the Wand computerized delivery system resulted in less painful injections and was better accepted by pediatric patients compared to traditional syringes. Mittal et al. also noted a significant reduction in pain perception when using the Wand for palatal infiltration in children aged 8 to 12 years compared to traditional methods.[8]

Buzzy System: The Buzzy System is a device designed in the shape of a bee, featuring two key components: detachable ice wings and body vibration. It operates based on the descending inhibitory controls and gate control theory. Specifically, the vibrations produced by the device block afferent pain-receptive fibers (A-delta and C fibers), effectively reducing discomfort.

Additionally, when applied near the site of nociception, continuous cold therapy stimulates the C nociceptive fibers while suppressing A-delta signals. According to Suohu et al., the Buzzy® system, which delivers cold and vibration externally next to the local anesthetic injection site, can alleviate pain and anxiety in children during local anesthesia administration for invasive dental procedures.[9]

Accupal: Accupal is a cordless device designed to condition the oral mucosa through a combination of vibration and pressure. Created by inventor Michael Zweifler, this tool applies pressure while vibrating the injection site in a 360-degree radius around the needle's infiltration point, effectively closing the "pain gate."

Once positioned at the injection site and with light pressure applied, the unit vibrates to enhance patient comfort. The battery-powered motor connects to the needle, which is placed in a hole with a disposable tip head for hygiene and ease of use.[5]

Insulin Syringe: The insulin syringe, featuring a miniature needle, slim design, and bright color, often resembles a toy to child patients. This similarity helps build confidence, making it easier to encourage children to undergo injections, ultimately reducing the time spent in dental appointments. The insulin syringe allows for almost pain-free injections through controlled and fractionated delivery of the anesthetic solution. Tirupathi et al. found that insulin syringes and auto-control syringes (ACS) demonstrated comparable efficacy in administering palatal anesthesia. Additionally, 96.5% of children preferred the visually appealing insulin syringes, suggesting they can serve as a cost-effective alternative to expensive ACS for palatal injections.[10]

3. ALTERNATIVE DENTAL ANESTHESIA

Electric Dental Anesthesia: Electric Dental Anesthesia is a commonly used non-pharmacological method for managing both acute and chronic pain. This technique employs transcutaneous electrical nerve stimulation (TENS), which utilizes an electrical current generated by a device to stimulate nerves, primarily for therapeutic purposes. Since the equipment does not involve any syringes, it encourages positive behavior in children and reduces their anxiety. Consequently, this method is particularly beneficial for pediatric patients.

Additionally, it proves to be effective for adult patients as well, providing analgesia during various dental procedures such as placing rubber dams, preparing cavities, capping pulp, conducting endodontic treatments, preparing prosthetic teeth, performing oral prophylaxis, and extracting teeth. It also helps alleviate discomfort during local anesthetic injections.[5]

Laser Analgesia: Laser Analgesia utilizes low-level laser therapy (LLLT) as a non-thermogenic, non-invasive method to biomodulate tooth pulp. Unlike infiltrative local anesthesia, LLLT does not produce profound anesthesia or complete loss of sensation. Instead, it temporarily disrupts the Na-K pump, altering neuronal cell activity to prevent impulse transmission and create an analgesic effect.

This approach helps reduce anxiety in children and teens, making them more accepting of laser dental treatments. Chan et al. demonstrated that the effectiveness of the Nd:YAG laser in achieving pulpal analgesia is comparable to that of 5% EMLA anesthetic cream. They also suggested that laser therapy represents a novel, non-invasive treatment option for children who have a fear of needles.[11]

Cryoanesthesia: Cryoanesthesia is a technique that involves cooling a specific area of the body with ice or refrigerant sprays to prevent nerves from transmitting pain signals. This application of cold stimulates inhibitory pain pathways and activates myelinated A-fibers. Cooling decreases the threshold of tissue nociceptors and impairs the conduction of pain signals, leading to neuropraxia.[12]

Hindocha et al. found that using 5% lidocaine gel during needle insertion has a similar effect to applying ice to the oral mucosa as a topical anesthetic prior to injection. The effects of the topical anesthetic last for a few minutes after application.[13]

Bose et al. suggest that precooling soft tissue areas before routine dental procedures can reduce pain perception during infiltrations and block anesthesia in children.[14]

This method is simple, reliable, and cost-effective. A comprehensive review by Tirupathi and Rajasekhar emphasizes the benefits of precooling with ice before procedures.

Maximum Recommended Dose: Local anesthetics can cause toxicity if the maximum dose is exceeded, leading to neurological and cardiac issues due to neural ischemia and inflammation. Early symptoms include excitatory signs like visual disturbances and seizures, which can progress to depression, reduced consciousness, coma, or respiratory failure. Cardiac complications may involve arrhythmias or even cardiac arrest. To prevent toxicity, it is essential to follow safe dosage limits based on the patient's weight. The anesthetic concentration, expressed as a percentage, indicates grams of anesthetic per 100 ml; for instance, a 2% lidocaine solution contains 20 mg/ml.

To calculate the total anesthetic dose in a cartridge, multiply the concentration in mg/ml by the cartridge volume (e.g., 20 mg/ml x 2.2 ml = 44 mg). A healthy adult weighing 70 kg can safely receive a maximum of 490 mg of lidocaine (7 mg/kg x 70 kg). Dividing the maximum dose by the mg per cartridge gives the number of cartridges (490 mg / 44 mg = 11.13 cartridges). This calculation can be adjusted for different weights and anesthetics. Potency, dose, and exposure time are key factors in toxicity, and children or frail patients may need smaller doses. Signs of toxicity include slurred speech, diplopia, tinnitus, and muscle twitching, often arising from accidental intravascular administration.[15]

Conclusion: In conclusion, the recent advances in local anesthesia techniques and agents signify a transformative shift in pain management within dentistry and surgery. With improved delivery systems, innovative anesthetics, and enhanced techniques, practitioners can significantly increase patient comfort and satisfaction while minimizing adverse effects. As these technologies continue to evolve, it is essential for healthcare providers to stay informed and adapt their practices accordingly. By embracing these advancements, clinicians can ensure more effective and compassionate care, ultimately leading to better outcomes and an enhanced patient experience.

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