REVIEW ARTICLE

Effective Strategies to Manage the Clinically Challenging Hot Tooth: A Review

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Abstract

Orofacial pain management requires successful and effective pain control measures. Intraoral local anesthetic administration is considered a safe and routine technique in dentistry but it becomes a significant challenge for endodontists to achieve profound anesthesia especially when dealing with "hot" tooth with irreversible pulpitis. Multiple factors have been implicated in the failure of local anesthesia in hot tooth which includes an incorrect technique of injection, variation in the foramina position, accessory innervations activation of nociceptors, and upregulated tetrodotoxin-resistant sodium (TTRx) channels. The standard technique for pulpal anesthesia is the inferior alveolar nerve block (IANB), but it has a failure rate of 30–80% in teeth with symptomatic pulpitis. Inadequate anesthesia can cause discomfort for both the patient and the clinician. But proper pain management restores faith and changes patients' emotional appeal throughout the procedure. Various strategies proposed to overcome the anesthetic failure include premedication, alternative anesthetics, supplementary injections, epinephrine ratio changes, anesthetic solution volume adjustments, acupuncture, and cryotherapy.

Keywords: Anesthesia, Intraligamentary, Intraseptal, Lidocaine, Premedication, Tetrodotoxin-resistant sodium channels.

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Introduction

Endodontic emergencies are the condition associated with pain and/or swelling requiring immediate diagnosis and treatment.[1] A major challenge faced by an endodontist is the successful management of endodontic pain with adequate anesthesia, especially when one adds the condition of a "hot" tooth. The term "hot" tooth generally refers to a pulp that has been diagnosed with irreversible pulpitis, with spontaneous, moderate-to-severe pain.[2] Inadequate anesthesia during endodontic treatment of inflamed teeth can cause discomfort for both the dentist and patient, leading to increased apprehension and distress for the clinician.[3] The highest incidence of hot teeth is encountered in mandibular molars with an incidence of 44–81%.[4] The inferior alveolar nerve block (IANB) is the standard technique for pulpal anesthesia in posterior mandibular teeth, but it has a failure rate of 41–81% in symptomatic irreversible pulpitis (SIP).[5] Clinicians must have thorough knowledge on tooth anatomy, foramina position, nerve supply, anesthetic diffusion barriers, tissue pH changes, and adjunctive methods to overcome anesthetic failure in irreversible pulpitis teeth. To manage hot tooth, different strategies have to be advocated preoperatively, perioperatively, and postoperatively to resolve the signs and symptoms of pain, inflammation when conventional methods fail to provide sufficient anesthesia in inflamed tissues. The aim of this review article is to discuss the various strategies to manage hot tooth both preoperatively and perioperatively.

Discussion

Successful management of pain has been considered as one of the keystones in endodontic practice for many decades. But, achieving profound pulpal anesthesia in patients with a hot tooth is still problematic, because the inflamed tissues are eight times more resistant to local anesthetics than normal tissue.[6]

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Reasons for Failure of Local Anesthetics in Hot Tooth

Anatomical Reasons

Dense cortical bone in mandibular molars acts as a barrier for anesthetic entry, while thinner bones in the maxilla facilitate diffusion. Accessory innervations and cross-innervation from the contralateral inferior alveolar nerve (IAN) has been implicated in failure to achieve anesthesia. Foramina position and tooth position also affect local anesthetic efficacy.[7]

Inflammation and Tissue pH

Inflamed tissue has a lower pH that brings down the amount of the base form of anesthetic that invade the nerve membrane. As a result, only a smaller extent of the ionized form is available in the nerve to attain anesthesia. Ion trapping is only possible in infiltration injections, block injections are not likely to be affected by tissue acidosis.[8]

Effect of Inflammation on Blood Flow

Inflammation has additional consequences on the physiology of local tissues. Inflammatory mediators cause peripheral vasodilation that adversely affects the systemic absorption of local anesthetics, lowers the concentration of local anesthetics at the site of action and the greater buffering capacity in inflamed tissues causes quicker elimination of anesthetics.[8]

Tetrodotoxin-resistant Channels (TTXr)

Tetrodotoxin channels are a special class of sodium channels present on C-fibers. During inflammation, the expression of prostaglandins makes these sodium channels in C-fibers shift the TTX-sensitive channels to TTX-resistant channels. The expression of TTX channels is doubled in inflamed dental pulp making them four resistant to local anesthetics, reduces the activation threshold of voltage-gated sodium channels (VGSCs) thereby increases the influx of Na ions across nerve membrane, resulting in failure of anesthesia. Tetrodotoxin-resistant channels represent a logical mechanism for local anesthetic failures.[8]

Activation of Nociceptors

Inflammatory mediators bring down the stimulation threshold of neurons during inflammation. As a result of inflammation, prostaglandin's (PG's) are formed as end products through cyclo-oxygenase pathway. Prostaglandin's increase the sensation of pain by enhancing the sensitivity of the nerve endings to inflammatory mediators such as bradykinin and histamine.[8]

Strategies Proposed to Manage Hot Tooth

Though different strategies have been proposed to manage hot tooth, a major attention has been on the reduction of inflammation prior to the administration of local anesthesia because the inflammatory mediators have greater potential to stimulate nociceptive fibers even at very low thresholds. To enhance the success of anesthetics, utilization of premedication strategies has sought desirable results in alleviating inflammation by decreasing the number of prostaglandins and inflammatory mediators which are the major causes of painful symptoms.[3]

Various Premedications Used for Management of Hot Tooth

Nonsteroidal Anti-inflammatory drugs (NSAIDs)

In dentistry, NSAIDs are the most frequently used analgesics. Premedication with NSAIDs inhibits the cyclooxygenase enzyme, lowering prostaglandin (PG) levels, especially PGE2. Prostaglandins are more effective at sensitizing nociceptor neurons on transmembrane VGSCs, making them more susceptible to inflammatory mediators that cause hyperalgesia.[3]

Ibuprofen

Ibuprofen, a nonselective COX inhibitor, is the safest conventional NSAID. In SIP, Noguera-Gonzales et al. found that premedication with 600 mg ibuprofen improved the efficiency of IANB significantly.[9]

Ibuprofen and Acetaminophen

Acetaminophen is a popular analgesic used to control endodontic pain, increasing pain threshold through brain interaction with cannabinoid and serotoninergic pathways. Combining ibuprofen and acetaminophen is proposed as an alternative, especially for NSAIDS-sensitive individuals with gastrointestinal ulcers or hypertension.[10]

Other NSAIDs

A study compared different combinations of NSAIDs (ketorolac, etodolac + paracetamol, and aceclofenac + paracetamol), the results of the study suggested IANB alone is not sufficient to obtain thorough anesthesia in mandibular symptomatic teeth and additional supplementary anesthesia is definitely needed along with premedication.[11]

Lornoxicam and diclofenac, both NSAIDs, have analgesic activity through cyclo-oxygenase inhibition. Preoperative administration of 8 mg LNX significantly improved the efficacy of IANBs in patients with irreversible pulpitis.[12] A study found that 20 mg piroxicam, given 1 hour before IANB, significantly reduced pain compared with 50 mg diclofenac potassium and 550 mg naproxen sodium.[13] And 10 mg ketorolac significantly improved the success rate of IANB in patients with irreversible pulpitis compared with 50 mg diclofenac. Ketorolac causes inhibition of C-fibers conduction that are more resistant to local anesthesia than A-delta fibers and also causes activation of nitric oxide–cyclic guanosine monophosphate (GMP) pathway through opening up of the K+ channels primary afferent nerve endings resulting in antinociception and also increasing the success rate of IANB.[14]

Selective Cox-2 Inhibitors

Rofecoxib and meloxicam are highly specific COX-2 inhibitors more effective than ibuprofen in reducing post-endodontic pain. Its longer analgesic efficacy, longer duration of action, lesser gastrointestinal toxicity, and lack of inhibition of platelet function and aggregation make it a preferred choice over other analgesics. About 50 mg rofecoxib was found to be more helpful in managing post-endodontic pain after 12 and 24 hours.[15,16] Meloxicam has a more favorable cardiovascular safety profile in comparison to other COX-2 inhibitors. Shantiaee et al. suggested the depth of IANB success was raised by 73.9% when 7.5 mg of meloxicam was used as pre-anesthetic medication.[17]

Pretreatment with Corticosteroids

Pretreatment with Prednisolone

Prednisolone, a steroidal anti-inflammatory drug, reduces inflammation by inhibiting proinflammatory cytokines and phospholipase A2 release lowering the levels of PG's and leukotriene. Jalalzadeh et al. suggested a single oral dose of 30 mg prednisolone administered 30 minutes before the endodontic procedure reduced post-endodontic pain.[18] Praveen et al. found single premedication of 30 mg prednisolone has a more sustained effect than 20 mg ketorolac.[19]

Ibuprofen and Dexamethasone

Dexamethasone is a steroidal anti-inflammatory drug that blocks the COX and lipoxygenase pathway essential for PG and leukotriene synthesis. Premedication of 800 mg ibuprofen and 0.5 mg dexamethasone enhanced the IANB success rate by 95.66%. Dexamethasone alone raised the success rate of IANB up to 85.72%, the dosage can be raised to 4 mg for better anesthetic efficacy.[20]

Premedication with Nitrous Oxide and Ketamine

Nitrous oxide, a commonly used inhalation anesthetic, acts on opiate and NMDA receptors for analgesia.[21] Ketamine, a derivative of phencyclidine, causes dissociative anesthesia by affecting nerve membranes and interacting with opioid, monoaminergic, muscarinic, and calcium channels, enhancing the anesthetic effect. Kaviani et al. reported that 10 mg of ketamine is beneficial for enhancing the local anesthetic effect.[22] Adverse effects (AE) associated with N_2O sedation is vomiting, diffusion hypoxia after cessation of N_2O, rarely irreversible inactivation of vitamin B_{12} severity of AEs depends on the duration of N_2O supply.[23]

Benzodiazepines (BZDP)

Benzodiazepines, like alprazolam, are used to alleviate discomfort and enhance the effectiveness of IANB by binding to specific GABA receptor sites, thereby reducing aberrant brain activity. A single oral preoperative dose of 0.5 mg alprazolam reduced anxiety and improved patient satisfaction but did not increase IAN block success.[24] Shetkar et al. found that 0.5 mg alprazolam premedication along with the Gow–Gates technique effectively managed acute pain in irreversible pulpitis.[25]

Acupuncture in Success of IANB

Acupuncture is a nonpharmacologic treatment used to improve the efficacy of an IANB in teeth with irreversible pulpitis and control pain in dentistry. Acupuncture involves inserting tiny needles into acupuncture sites (also called acupoints) on the body's surface. LI4 Hegu is a single acupuncture point that has long been used to relieve oral and masticatory muscle discomfort. When the needle is inserted into an acupuncture point, the patient will experience De qi (Composite of sensations felt at the needling site after adequate needle insertion with or without proper manipulation) which manifests as numbness, heaviness, or distention around the insertion site. Acupuncture application prior to endodontic treatment was reported to boost the efficiency of IANBs by up to 60% in SIP.[26]

Perioperative Strategies to Manage Hot Tooth

- Alteration in anesthetic solution.
- Cryotherapy.
- Supplemental anesthetic techniques.

Alteration in Anesthetic Solution

Addition of dexamethasone to lidocaine (Twin mix): Dexamethasone, a glucocorticoid, effectively relieves pain in SIP patients. The combination of lidocaine and dexamethasone not only improves sensory blockage, but it also raises the pH and free base concentration in the local anesthetic solution. Because of the higher pH, there is less discomfort or burning feeling at the injection site. A single injection of 1.8 mL 2% lidocaine with 1:200,000 epinephrine and 1 mL 4 mg dexamethasone decreased anesthetic latency and increased anesthesia duration.[27]

Addition of mannitol to lidocaine: Addition of mannitol to lidocaine expanded the perineurial membrane and increased the penetrability of lipophilic substance (such as lidocaine) with additional effect of slowing or stopping the action potential propagation in specific neurons. Adding 0.5 M mannitol to a lidocaine with 1:200,000 epinephrine formulation resulted in much higher percentage pulpal anesthesia than a lidocaine without mannitol.[28]

Clonidine as a vasoconstrictor alternative to epinephrine: Clonidine, a centrally and peripherally acting alpha-2 adrenoceptor agonist used to treat hypertension. Clonidine reduces vascular uptake of local anesthetics and increases pain threshold by vasoconstriction of peripheral blood vessels, directly inhibiting C-fibers and A-delta fibers compared with epinephrine-containing local anesthetics and considered as safe vasoconstrictor alternative to epinephrine because of its lower cardiotoxic side effects.[29,30] Shadmehr et al. found that adding 15 gm/mL of clonidine to a lidocaine solution resulted in much better IANB anesthesia.[31]

Addition of magnesium sulfate: Overexpression of N-methyl-D-aspartate (NMDA) receptors by central sensitization is one of the reasons for anesthetic failure. Magnesium sulfate is a noncompetitive NMDA receptor antagonist that interferes with NMDA receptors and reduces nociceptor-induced central sensitization. Shetty et al. reported that 1 mL magnesium sulfate USP 50% can be given preoperatively to boost anesthetic efficacy due to its potential calcium channel-blocking action that propagates pain.[32]

Addition of sodium bicarbonate to local anesthesia: Alkalinization of local anesthetics can alleviate pain by increasing the dissociation rate and uncharged base form. Buffered LA reduces injection pain, accelerates anesthesia onset, and improves anesthesia success rate. Shurtz et al. reported that buffered 2% lidocaine improved the efficacy of IANB.[33]

Amitriptyline local gel as a conjunctive to local anesthetics: Amitriptyline is one of the most commonly used tricyclic anticyclic depressants (TCA). Adding amitriptyline gel directly into the pulp cavity increases the analgesic activity by having synergistic effect on the co-inhibition of Na-channels on pain sensory fibers, local anesthetic activity might be partly mediated by pressure-induced changes in pulp space. About 0.4 mg of amitriptyline local gel effectively complements local anesthetics in treating irreversible pulpitis pain.[34]

Change in anesthetic volume or apeed: Increasing anesthetic volume from 1.8 mL of 2% lidocaine with 1:100,000 epinephrine to 3.6 mL of 2% lidocaine with 1:100,000 epinephrine made no significant difference in the efficacy of the injection. There was no statistically significant difference in the success of IANB in patients with SIP with 3.6 mL of 2% lidocaine with 1:100,000 epinephrine whether the injections were given at a rapid pace (30 seconds) or slow pace (120 seconds).[35]

Prewarming or preheating the anesthetic solution: Prewarming or preheating the anesthetic solution to 37–42°C has reduced intraoperative pain and discomfort when compared with conventional LA.[36]

Cryotherapy

Cryotherapy is one of the established procedures used in dentistry for pain relief and postoperative care. Applying cold to the tissues lowers the temperature, causing blood vessels to contract. Cryotherapy has an additive impact of delaying brain impulses by lowering the release of chemical mediators involved in pain transmission. By reducing the activation threshold of nociceptors and the conduction velocity of pain signals, cryotherapy also produces a local anesthetic effect. Keskin et al. found that irrigating root canals with a cold sterile saline solution at 2.5°C for 5 minutes reduced postoperative discomfort.[37]

Supplemental Anesthetic Techniques

When the typical IANB fails in both asymptomatic and symptomatic patients, a dentist must have fallback techniques to achieve excellent pulpal anesthesia, especially when a patient complains of pain that is too severe to manage, there are several supplemental injection techniques.

- Intraligamentary injection.
- Buccal infiltration.

- Submucosal injection.
- Intraosseous technique.
- Intraseptal technique.
- Gow–Gates technique.
- Vazirani–Akinosi Technique.

Intraligamentary injection (IL): Intraligamentary injection is one of the supplemental injections in patients with SIP. IL involves depositing 0.2 mL of local anesthetic solution into the periodontal space between the tooth root and alveolar bone using a 27–30G needle at an angle of 30–40°, up to a subgingival depth of 2–3 mm.[38,39]

Intraligamentary injection is a viable supplemental injection with a success rate of 84% after a failed primary IANB. Anesthetic efficacy of IANB with buccal infiltration plus IL has increased the success rate of up to 58%. Aggarwal et al. in their study compared the anesthetic efficacy of 4% articaine vs 2% lidocaine as supplemental IL after a failed IANB.[40] The success rate of PDL injection increased up to 76% with Computer Controlled Local Anesthetic Delivery System (C-CLAD™).[41]

Buccal infiltration: Supplemental buccal infiltration of 4% articaine with 1:100,000 epinephrine has raised the success rate up to 58% in failed IANB.[42] Repeated buccal infiltration of 4% articaine with 1:100,000 epinephrine significantly increased the duration of pulpal anesthesia from 28 to 109 minutes.[43] 4% articane provides adequate pulpal anesthesia when compared with 4% lidocaine and 4% prilocaine in the primary buccal infiltration technique.[44] McEntire et al.'s concluded that varying epinephrine concentrations did not significantly affect anesthetic efficacy.[45] Due to the presence of thiophene ring, articaine exhibits high liposolubility and superior diffusion through bony tissue and longer duration of action comparable to other local anesthetics.

Submucosal infiltration: Submucosal infiltration is a supplemental injection administered to the buccal of the affected tooth in addition to standard IANB. Pulpal anesthesia increased up to 57% with preoperative administration of submucosal 50 mg tramadol in addition to standard IANB.[46] 100 mg tramadol submucosal infiltration in addition to standard IANB with 2% lidocaine provided a success rate of 48.6%. Preoperative submucosal infiltration of 8 mg dexamethasone has increased the pulpal anesthesia success rate up to 47%.[47]

Intraseptal technique: Intraseptal anesthesia involves direct deposition of anesthetic solution into the interdental septum through the crestal alveolar bone. It simplifies the process by perforating the cortical plate with the anesthetic needle, eliminating the need for a perforating device.

A success rate of 29% was obtained with 4% articaine intraseptal injection after the failure of conventional IANB. It was found that IANB with 1.7 mL of 2% lidocaine with 1:1,00,000 epinephrine along with supplemental intraseptal injection of 0.85 mL of 4% articaine with 1:100,000 epinephrine and additional buccal infiltration of 1.7 mL of 4% articaine with 1:100,000 epinephrine produced a greater success of 80% than IANB + BI or IANB alone with a success rate of 66.66, 30.33%, respectively in SIP.[48,49]

Intraosseous (IO) anesthetic technique: The intraosseous technique involves the local anesthetic solution deposition directly into the porous cancellous bone around the tooth using a port or perforating system.[50] Intraosseous anesthetic technique had a higher success rate than IANB with success rates increasing up to 90% when given as supplemental anesthesia.[51]

Gow–gates technique (Wide open mouth technique): Dr Gow–Gates introduced a true mandibular nerve block, providing sensory anesthesia to the entire mandibular trigeminal division using extraoral landmarks and a single intraoral injection puncture point exposing all branches of the mandibular nerve to anesthetic solution, significantly longer than IANB. Aggarwal et al. found that 2.2 mL of 4% articaine with 1:100,000 adrenaline by the Gow–Gates mandibular anesthesia increased the success rate of pulpal anesthesia by 53% in patients with irreversible pulpitis compared with IANB. However, limitations of this technique include dependence on extra-oral landmarks, operator learning skills, and reduced mouth openings.[40]

Vazirani–akinosi technique (Reduced mouth opening technique): Akinosi developed a closed mouth IANB technique for endodontic emergencies for patients with reduced mouth opening. This technique involves the insertion of needle just medial to the ramus of the mandible, at the level of the gingival margins of maxillary molars in a closed mouth position depositing the local anesthesia solution into pterygomandibular space. A modified version deposits LA at higher level than IANB.[50] A success rate of 41% was achieved with technique which was statistically insignificant.[40] It is highly advantageous in conditions with limited mouth opening where a major limitation being no bony contact end point during needle insertion leading to deposition of local anesthetic in maxillary artery or pterygoid plexus leading to hematoma formation.[52]

Intrapulpal anesthesia: About 5–10% of mandibular posterior teeth with irreversible pulpitis require intrapulpal injection for anesthesia. It relies on the deposition of 0.2 mL anesthetic solution directly into the pulp chamber under pressure. An opening into the pulp should be made with a small round bur to allow the snug fit of the needle. If opening is large enough, then the needle should be advanced into the canal until the fit is tight to ensure no back flow of anesthetic solution through large pulpal opening. This technique offers advantages like minimal local anesthetic volume, negligible systemic effects, painless injection but has limited application because it requires pulpal exposure, and it is not indicated as a primary method of anesthesia.[7]

Summary

Though different strategies have been proposed to enhance the success of IANB, anesthesia in SIP articaine and mepivacaine are preferred for mandibular infiltrative anesthesia in SIP. Combining Ibuprofen with other NSAIDs improves IANB success rates. Acetaminophen can be used for premedication if NSAIDs are contraindicated. Nitrous oxide and sedatives may be preferred in apprehensive patients. The addition of clonidine to lidocaine improves IANB success. Clinicians should always have a fallback on appropriate supplemental anesthesia if needed, the attitude of the practitioner as well as the emergency procedure itself influence patient satisfaction.

Clinical Significance

In everyday practice, the incidence of hot tooth is common. Achieving profound pulpal anesthesia in individuals, particularly those with hot tooth and irreversible pulpitis, can be extremely difficult. This article highlights the numerous etiological variables for anesthetic failure as well as some of the most efficient approaches for managing "hot" tooth.

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