



Selection Factors for Local Anesthetic Agents

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ABSTRACT The decision to inject local anesthetic agents to achieve profound anesthesia is dependent upon many factors, particularly the depth and duration of anesthesia required, and the possible need for hemostasis. To maximize the safety of local anesthetic injections, it is necessary to weigh the risks against the benefits for each patient, for each anesthetic agent, for use of a vasoconstrictor, and for the delivery technique for the selected agent.

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The administration of local anesthetic agents via intraoral injection is fundamental to the establishment and management of patient pain in the majority of dental procedures. Although dentists and, in most states, hygienists receive extensive training and practice in the administration of local anesthetic injections, many variables can affect the attainment of successful anesthesia in dental patients.

Clearly there are significant human variables: anatomical variations in the size, morphology and location of structures in the jaws of different individuals, and of the dental sensory nerve pathways themselves, are well recognized.^{1,2} Variations in chemical sensitivity from one

person to another are also significant: Any given patient will not be equally sensitive to all of the anesthetic agents available for dentistry, nor will any patient necessarily experience the same degree of anesthesia from any single anesthetic agent from one appointment to another.

Some of this variability is attributable to differences in the numbers, types, and physiologic state of anesthetic binding sites within sensory nerves.³ This article will discuss some general properties of the anesthetic agents available in dental injection cartridges and will offer suggestions for achieving more predictable success with dental local anesthesia. **TABLE 1** lists the anesthetic agents currently available in dental injection cartridges in the United States.

The Development of Dental Local Anesthetic Agents

Historically, the first local anesthetic agent widely used in dentistry was cocaine. The first injection of cocaine for nerve conduction blockade is attributed to noted American surgeon William Halstead in November 1884 when he performed infraorbital and inferior alveolar nerve blocks for dental procedures.⁴

Although injection of cocaine provided a major advancement in pain control, it had significant drawbacks, such as a high propensity for addiction and a short duration of action. This latter factor necessitated injection of large doses of the drug, which further increased the potential for addiction and for severe systemic toxicity.

The safety of nerve conduction blockade procedures advanced tremendously in 1905 when Alfred Einhorn and his associates synthesized an ester-based local anesthetic, named procaine.⁵ As a safe and effective substitute for cocaine, the discovery of procaine, marketed under the trade name Novocain, is considered by some historians to mark the beginning of the modern era of regional anesthesia. Development of several other ester-type local anesthetics followed and these remained in wide use throughout most of the 20th century.

The next step forward occurred in 1943 when Nils Löfgren synthesized a new amide-based local anesthetic agent, derived from xyloidine, and named it "lidocaine."⁶ First marketed in 1948 under the trade name Xylocaine, lidocaine was more potent and less allergenic than procaine and the other ester-based anesthetics. Several other amide anesthetics have since been developed and remain in use in dentistry: mepivacaine, prilocaine, bupivacaine, and articaine. The advantages of the amide-based

TABLE 1

Local Anesthetic Agents Available in the United States

All of the anesthetic agents currently available in a dental injection cartridge in the United States are of the amide chemical class.

- Lidocaine HCl: 2% plain or 2% with 1:50,000 or 1:100,000 epinephrine
- Mepivacaine HCl: 3% plain or 2% with 1:20,000 levonordefrin (Neo-Cobefrin)
- Prilocaine HCl: 4% plain or 4% with 1:200,000 epinephrine
- Articaine HCl: 4% with 1:100,000 or 1:200,000 epinephrine
- Bupivacaine HCl: 0.5% with 1:200,000 epinephrine

anesthetic agents, particularly their extremely low rate of allergenicity as compared to the ester-type anesthetics (almost nonexistent for amides versus about 1 percent of the population for the esters), led to their complete replacement of the ester-based anesthetics in dental injection cartridges.⁷

Use of Currently Available Dental Local Anesthetic Agents

The availability of a variety of local anesthetic agents enables dentists and hygienists to select an anesthetic that possesses specific properties such as time of onset and duration, hemostatic control, and degree of cardiac side effects that are appropriate for each individual patient and for each specific dental procedure. **TABLE 2** briefly summarizes the properties of the anesthetic agents currently available for dental use in the United States. It should be noted that these properties, particularly duration and depth of anesthesia, are quite variable due to a number of factors and are therefore only approximations.⁷

1. Accuracy in administration of the drug
2. Anatomical variation
3. Status of the tissues at the site of drug deposition (vascularity, pH)
4. Type of injection administered (infiltration versus nerve block)
5. Individual variation in response to the drug administered

The Relation of Anesthetic Agent Selection to Injection Technique

Although technique is not everything, it is important, the technique must be matched to the anesthetic agent to achieve the desired anesthesia goals. After deciding that the outcome of a patient's dental procedure will benefit from use of a local anesthetic injection, the decision must be made between an infiltration injection technique and a block injection technique. A block injection will generally provide adequate anesthesia for approximately twice as long as an infiltration injection. However, there are some anesthetic agents for which this generality does not hold true. For example, prilocaine 4 percent HCl "plain" when administered as an infiltration injection for maxillary teeth has a pulpal anesthesia duration of only about 10 minutes, as determined by electrical stimulation studies.⁹

When injected via a block technique, this same anesthetic agent produces pulpal anesthesia from 40 to 60 minutes.⁷ With the addition of a vasoconstrictor agent (prilocaine 4 percent HCl with 1:200,000 epinephrine), the pulpal anesthesia duration times of this anesthetic agent are less technique sensitive and can extend up to one hour as an infiltration injection and up to 90 minutes as a block injection.⁷

Another example is bupivacaine (0.5 percent HCl with 1:200,000 epinephrine), which is potentially the longest-acting anesthetic agent available in a dental cartridge. If administered via an

TABLE 2

Characteristics of Local Anesthetic Agents^{7,8}

| Local Anesthetic | Onset* | Duration of Pulpal Anesthesia** |
|-----------------------------------|---------------------------|---|
| 2% Lidocaine plain | Fast: 3 to 5 minutes | Short: 5 to 10 minutes not recommended for nerve blocks |
| 2% Lidocaine with epinephrine | Fast: 3 to 5 minutes | Moderate: 60 to 90 minutes |
| 3% Mepivacaine plain | Fast: 3 to 5 minutes | Short: 20 to 40 minutes |
| 2% Mepivacaine with levonordefrin | Fast: 3 to 5 minutes | Moderate: 40 to 90 minutes |
| 4% Prilocaine plain | Fast: 3 to 5 minutes | Moderate: 10 to 60 minutes |
| 4% Prilocaine with epinephrine | Fast: 3 to 5 minutes | Moderate: 35 to 70 minutes |
| 4% Articaine with epinephrine | Fast: 2 to 3 minutes | Moderate: 60 to 120 minutes |
| 0.5% Bupivacaine with epinephrine | Moderate: 6 to 10 minutes | Long: Up to 7 hours |

*Time of onset: Individual variances are common. Lower number provided is average for infiltration injections; higher number is average for nerve block injections.

**Duration of pulpal anesthesia: Individual variances are common. Lower number provided is average for infiltration injections; higher number is average for nerve block injections.

infiltration injection technique in the maxilla, it has an average pulpal anesthesia duration of only 40 minutes, which is normally not as long as the duration of the same injection using lidocaine or mepivacaine.^{7,10} The long duration of pulpal anesthesia with bupivacaine, up to four hours in some patients, is realized only when this agent is administered as a block injection.¹⁰ However, it must be noted that exactly how long pulpal anesthesia will last for either type of injection with any agent is dependent upon a number of patient variables, and also upon the relative volume of anesthetic injected, the accuracy of administration of the technique used, and the presence or absence of a vasoconstrictor agent.

The Use of Vasoconstrictor Agents

The presence or absence of a vasoconstrictor has significant effects on the properties of an anesthetic agent. This is due to three main factors: (1) increased duration of anesthesia by holding the anesthetic at the local injection site longer by constriction of the local vasculature; (2) localized vasoconstrictor-

tion can maintain hemostasis during dental procedures, such as root planing or surgical procedures that produce bleeding; and (3) slowed uptake of the anesthetic agent into the bloodstream, resulting in a lower concentration of anesthetic in the blood over time, which reduces the risk of systemic toxicity.¹¹⁻¹³

Use of a block injection technique, which is usually given at a site some distance from the procedure site, may provide adequate pulpal and gingival anesthesia; however, it cannot provide adequate hemostasis at the procedure site; only local infiltrations close to the actual site of bleeding can effectively control bleeding.⁷ Conversely, local infiltration injections may provide both local site anesthesia and hemostasis, but the duration of anesthesia is shorter and may be a less profound level of anesthesia. In order to decide which technique to use, the practitioner must consider the depth and duration of anesthesia required for the procedure and the possible need for hemostasis at the local site. For invasive root planing or surgical procedures, it may be best to use a combination of both techniques: a block injection with a vasocon-

strictor-containing anesthetic for depth and duration of anesthesia, and infiltration injections with the same or a higher vasoconstrictor concentration for hemostasis.

Although the presence of a vasoconstrictor increases the duration of anesthesia, the specific concentration of the vasoconstrictor does not alter the clinical duration of anesthesia by more than a few minutes.^{7,13-15} For example, lidocaine with epinephrine is available in the United States in both 1:50,000 and 1:100,000 vasoconstrictor concentrations. The 1:50,000 concentration of epinephrine will provide the best hemostasis when used as a local site infiltration injection.^{7,14}

A block injection with the same 1:50,000 concentration will not provide significantly longer pulpal duration of anesthesia than a 1:100,000 concentration but is more likely to produce systemic cardiovascular side effects, such as tachycardia.^{13,14} It is the author's recommendation to use the 1:50,000 concentration only for local infiltration injections and to use the lower 1:100,000 concentration for block injections. For patient safety reasons, the lowest concentration of vasoconstrictor available is generally preferable for all block injections.

Vasoconstrictor Agents

In the United States, epinephrine is the primary vasoconstrictor agent used in dental anesthetics. Levonordefrin (Neo-Cobefrin, Cook-Waite/Kodak) in a 1:20,000 concentration is used only with a 2 percent mepivacaine formulation in North America. Because levonordefrin has a reduced tachycardic effect on the heart, it is preferable to use for particularly epinephrine-sensitive patients. However, levonordefrin is contraindicated for use in all patients for whom epinephrine is contraindicated, i.e., if epinephrine should not be used because of its possible deleterious effect on the patient's medical condition,

levonordefrin should not be substituted.¹⁶ A plain anesthetic solution without a vasoconstrictor agent should be used in the infrequent situation where use of a vasoconstrictor is medically contraindicated.

The Use of Articaine in Patients with 'Sulfur' Allergies

Articaine has become a popular dental anesthetic in the United States since its introduction in April 2000. Although classified as an amide anesthetic agent and sharing the amide characteristic of extremely low risk of allergenicity in the population, articaine is actually a hybrid of both an amide and an ester class anesthetic due to the presence of both an amide and an ester intermediate chain in its chemical composition. Biotransformation of articaine begins immediately upon its entering the bloodstream where the plasma esterase enzymes initiate the metabolic breakdown process via hydrolysis of the ester chains. Articaine metabolism is then completed in the liver by hepatic microsomal enzymes.¹⁷

Metabolism of all other amide anesthetic agents does not begin until they reach the liver. The more rapid metabolism of articaine suggests that articaine has a reduced risk of systemic toxicity; however, it must be remembered that articaine is available only in the higher 4 percent concentration in the United States.

Articaine is also unique in that its aromatic ring structure is a thiophene ring rather than the benzene ring characteristic of all other amide agents, a feature which significantly increases articaine's lipid solubility.⁷ Contained within the thiophene ring structure of articaine is a sulfur molecule, which has led some practitioners to avoid the use of articaine in patients with sulfur and sulfa drug allergies. However, the sulfur molecule is a nonallergen, making its presence allergenically immaterial.^{7,18}

Patient sulfur and sulfa drug allergies are largely caused by the sulfonamide drugs, such as bactrim and sepra, or to the sodium metabisulfite used as an anti-oxidant agent to protect the vasoconstrictor in local anesthetic cartridges. To assess a patient's possible reactivity to sodium metabisulfite the dentist or hygienist should question the patient about possible food allergies.

Because foods such as dried fruits and preserved meats (pepperoni, salami) or beer and wine contain high levels of sulfites, if a patient avoids these types of food items, it is best advised to avoid all anesthetic solutions containing any form of vasoconstrictor. Unfortunately, the use of only plain anesthetics in these situations provides relatively short duration of pulpal anesthesia and may result in the need for repeated anesthetic injections.

Conclusion

The selection of a technique for administering local anesthesia injections is important to the overall goals of local anesthetic use in dental procedures: adequate anesthesia to maintain patient comfort throughout the duration of the specific procedure, maintenance of hemostasis when bleeding is anticipated, and delivery of the anesthetic agent of choice in as safe and atraumatic a manner as possible. The selection of the anesthetic agent to be used must then be matched to the chosen injection technique.

Of paramount importance throughout this decision-making process is the fact that injection of dental local anesthetic agents is an invasive procedure, and, although the agents available to the profession in dental cartridges are remarkably safe, complications may occur in any patient at any time. Selection of which local anesthetic agent(s) to use must be based on careful goal and risk versus benefit assessments for each individual patient at each individual procedure appointment. ■■■■

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