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How to minimize the pain of local anesthetic administration

Expertise in the delivery of effective local analgesia is critical to the success of in-office procedures. Here's how to optimize patient outcomes and satisfaction.

PRACTICE RECOMMENDATIONS

› *Add epinephrine and sodium bicarbonate buffer to local anesthetic solution to reduce pain and procedural blood loss.* Ⓐ

› *Use such techniques as counter-stimulation, a perpendicular angle of injection, a subcutaneous depth of injection, and a slow rate of injection to minimize patient discomfort.* Ⓐ

Strength of recommendation (SOR)

Ⓐ Good-quality patient-oriented evidence

Ⓑ Inconsistent or limited-quality patient-oriented evidence

Ⓒ Consensus, usual practice, opinion, disease-oriented evidence, case series

In-office procedures are increasingly emphasized as a way to reduce referrals, avoid treatment delay, and increase practice revenue. Local analgesia is administered before many in-office procedures such as biopsies, toenail removal, and laceration repair. Skin procedures are performed most commonly; nearly three-quarters (74%) of family physicians (FPs) provided these services in 2018.[1] Administration of local anesthetic is often the most feared and uncomfortable step in the entire process.[2]

Knowledge of strategies to reduce pain associated with anesthetic administration can make a huge difference in the patient experience. This article explores evidence-based techniques for administering a local anesthetic with minimal patient discomfort.

4 factors influence the pain of local anesthetic administration

Pain is perceived during the administration of local anesthetic because of the insertion of the needle and the increased pressure from the injection of fluid. The needle causes sharp, pricking "first pain" via large diameter, myelinated A-delta fibers, and the fluid induces unmyelinated C-fiber activation via tissue distention resulting in dull, diffuse "second pain."

Four factors influence the experience of pain during administration of local anesthetic: the pharmacologic properties of the anesthetic itself, the equipment used, the environment, and the injection technique. Optimizing all 4 factors limits patient discomfort.

Pharmacologic agents: Lidocaine is often the agent of choice

Local anesthetics differ in maximal dosing, onset of action, and duration of effect (TABLE[3]). Given its ubiquity in clinics and hospitals, 1% lidocaine is often the agent of choice. Onset

TABLE

Characteristics of local anesthetics[3]

Local anesthetic	Onset (min)	Duration (min)	Duration with epinephrine (min)	Maximum dose (mg/kg)	Maximum dose with epinephrine (mg/kg)
INJECTABLE LOCAL ANESTHETICS					
Bupivacaine	2-10	120-240	240-480	2.5	3
Chloroprocaine	5-6	30-60	N/A	11	14
Etidocaine	3-5	200	240-360	4.5	6.5
Lidocaine	< 1	30-120	60-400	4.5	7
Mepivacaine	3-20	30-120	60-400	6	7
Prilocaine	5-6	30-120	60-400	7	10
Procaine	5	15-90	30-180	10	14
Tetracaine	7	120-240	240-480	2	2
TOPICAL LOCAL ANESTHETICS					
EMLA	< 60	60-120	N/A		
LMX-4	< 2	30-45	N/A		

N/A, not applicable.

Adapted with permission from: Kouba DJ, LoPiccolo MC, Alam M, et al. Guidelines for the use of local anesthesia in office-based dermatologic surgery. *J Am Acad Dermatol*. 2016;74:1201-1219.

of effect occurs within minutes and lasts up to 2 hours. Alternative agents, such as bupivacaine or ropivacaine, may be considered to prolong the anesthetic effect; however, limited evidence exists to support their use in office-based procedures. Additionally, bupivacaine and ropivacaine may be associated with greater pain on injection and paresthesias lasting longer than the duration of pain control.[4-6] In practice, maximal dosing is most important in the pediatric population, given the smaller size of the patients and their increased susceptibility to toxicity.

Calculating the maximum recommended dose. To calculate the maximum recommended dose of local anesthetic, you need to know the concentration of the anesthetic, the maximum allowable dose (mg/kg), and the weight of the patient.[7,8] The concentration of the local anesthetic is converted from percentage to weight per unit volume (eg, 1% = 10 mg/mL; 0.5% = 5 mg/mL). Multiply the patient's weight (kg) by the maximum dose of local anesthetic (mg/kg) and divide by the concentration of the local anesthetic (mg/mL) to get the maximum recommended dose in milliliters. Walsh et al[9] described a simplified formula to calculate the maximum allowable volume of local anesthetics in milliliters:

(maximum allowable dose in mg/kg) × (weight in kg) × (1 divided by the concentration of anesthetic).

For delivery of lidocaine with epinephrine in a 50-lb (22.7-kg) child, the calculation would be (7 mg/kg) × (22.7 kg) × (1 divided by 10 mg/mL) = 15.9 mL.

The advantages (and misconceptions) of epinephrine

The advantage of adding epinephrine is that it prolongs the effect of the anesthesia and it decreases bleeding. Epinephrine is commonly available as a premixed solution with lidocaine or bupivacaine at a concentration of 1:100,000 and is generally differentiated from "plain" local anesthetic by a red label and cap. Although maximum vasoconstriction may occur as long as 30 minutes after injection,[10] adequate vasoconstriction is achieved in 7 to 10 minutes for excision of skin lesions.[11]

Traditional teaching recommends against using epinephrine in the "fingers, toes, penis, ears, or nose" because of poten-

Add epinephrine to the anesthetic solution to prolong anesthesia and decrease bleeding.

tial arterial spasm, ischemia, and gangrene distal to the injection site.[12] These concerns were based on experiences with procaine and cocaine mixed with epinephrine. Studies suffered from multiple confounders, including tourniquets and nonstandardized epinephrine concentrations.[13-15]

No association of distal ischemia with epinephrine use was identified in a recent Cochrane Review or in another multicenter prospective study.[16,17] Phentolamine, a nonselective alpha-adrenergic receptor antagonist and vasodilator, can be administered to reverse vasoconstriction following inadvertent administration of high-dose epinephrine (1:1000) via anaphylaxis autoinjector kits.

Dosing of phentolamine is 1 mL of 1 mg/mL solution delivered subcutaneously to the affected area; reversal decreases the duration of vasoconstriction from 320 minutes to approximately 85 minutes.[18] As always, when applying literature to clinical practice, one must keep in mind the risks and benefits of any intervention. As such, in patients with pre-existing vascular disease, vaso-occlusive or vasospastic disease, or compromised perfusion due to trauma, one must weigh the benefits of the hemostatic effect against potential ischemia of already susceptible tissues. In such instances, omitting epinephrine from the solution is reasonable.

The benefits of sodium bicarbonate

The acidity of the solution contributes to the level of pain associated with administration of local anesthesia. Previously opened containers become more acidic.[19] Addition of 8.4% sodium bicarbonate, at a ratio of 1 mL per 10 mL of 1% lidocaine with 1:100,000 epinephrine, neutralizes the pH to 7.4.[19] A Cochrane Review showed that correction of pH to physiologic levels results in a significant reduction in pain.[20]

This solution can be easily prepared, as standard syringes hold an additional milliliter (ie, 10-mL syringes hold 11 mL) and, thus, can accommodate the additional volume of bicarbonate.[21]

Warming the solution helps, too

Warming the solution to body temperature prior to injection decreases pain on injection.[22] This may be done in a variety of ways depending on available in-office equipment. Water baths, incubators, fluid warmers, heating pads, or specific syringe warmers may be used. Multiple studies have shown improvement in patient satisfaction with warming.[23] Moreover, warming and buffering solution provide a synergistic effect on pain reduction.[23]

Equipment: Size matters

Smaller diameter needles. Reducing the outer diameter of the needle used for injection improves pain by reducing activation of nociceptors.[24-26] Reduced inner diameter restricts injection speed, which further reduces pain.[25] We recommend 27- to 30-gauge needles for subcutaneous injection and 25- to 27-gauge needles for intra-articular or tendon sheath injections.

Appropriate syringe size. Filling a syringe to capacity results in maximal deployment of the plunger. This requires greater handspan, which can lead to fatigue and loss of control during injection.[26,27] Using a syringe filled to approximately half its capacity results in improved dexterity. We recommend 10-mL syringes with 5 mL to 6 mL of local anesthetic for small procedures and 20-mL syringes filled with 10 mL to 12 mL for larger procedures.

Topical local anesthetics may be used either as an adjunct to decrease pain during injection or as the primary anesthetic.[28] A variety of agents are available for clinical use, including eutectic mixture of local anesthetics (EMLA), lidocaine-epinephrine-tetracaine (LET), lidocaine, benzocaine, and tetracaine. FPs should be familiar with their different pharmacokinetic profiles.

EMLA is a mixture of 25 mg/mL of lidocaine and 25 mg/mL of prilocaine. It is indicated for topical anesthesia on intact, nonmucosal, uninjured skin (maximal dose 20 g/200 cm^2 of surface area). It is applied in a thick layer and covered with an occlusive dressing (eg, Tegaderm) to enhance dermal penetration. The depth of penetration increases with application time and may reach a maximum depth of 3 mm and 5 mm following 60-minute and 120-minute application times, respectively.[28] Duration of effect is 60 to 120 minutes.

LET, which is a mixture of 4% lidocaine, 0.1% epinephrine, and 0.5% tetracaine, may be used on nonintact, nonmucosal surfaces. Typically, 1 mL to 5 mL of gel is applied directly to the target area and is followed by application of direct pressure for 15 to 30 minutes. LET is not effective on intact skin and is contraindicated in children < 2 years of age.[28]

Cooling sprays or ice. Topical skin refrigerants, or vapocoolants (eg, ethyl chloride spray), offer an option for short-term local anesthesia that is noninvasive and quick acting. Ethyl chloride is a gaseous substance that extracts heat as it evaporates from the skin, resulting in a transient local conduction block. Skin refrigerants are an option to consider for short procedures such as intra-articular injections, venipuncture, or skin tag excision, or as an adjunct prior to local anesthetic delivery.[29-32] Research has shown that topical ethyl chloride spray also possesses antiseptic properties.[29,33]

Environment: Make a few simple changes

Direct observation of needle penetration is associated with increased pain; advising patients to avert their gaze will mitigate the perception of pain.[34] Additionally, research has shown that creating a low-anxiety environment improves patient-reported outcomes in both children and adults.[35] Music or audiovisual or multimedia aids, for example, decrease pain and anxiety, particularly among children, and can be readily accessed with smart devices.[36-39]

We also recommend avoiding terms such as "pinch," "bee sting," or "stick" in order to reduce patient anxiety. Instead, we use language such as, "This is the medicine that will numb the area so you will be comfortable during the procedure."[40]

Injection technique: Consider these helpful tips

Site of needle entry. Prior to injecting local anesthesia, assess the area where the procedure is planned (**FIGURE 1**). The initial injection site should be proximal along the path of innervation. If regional nerves are anesthetized proximally and infiltration of local anesthesia proceeds distally, the initial puncture will be painful; however, further injections will be through anesthetized skin. Additionally, consider and avoid regional vascular anatomy.[41,42]

Counter-stimulation. Applying firm pressure, massaging, or stroking the site prior to or during the injection decreases pain.[43,44] This technique may be performed by firmly pinching the area of planned injection between the thumb and index fingers, inserting the needle into the pinched skin, and maintaining pressure on the area until the anesthetic effect is achieved.

Angle of needle insertion. Perpendicular entry of the needle into the skin appears to reduce injection site pain (**FIGURE 1**). Anecdotal reports are supported by a randomized, controlled crossover trial that demonstrated significantly reduced pain with perpendicular injection compared to delivery at 45°.[45]

Depth of injection. Subcutaneous needle placement is associated with significantly less pain than injection into superficial dermis.[2,46] Dermal wheals cause distention of the dermis, increased intradermal pressure, and greater activation of pain afferents in comparison to injection in the subcutaneous space.[46] One important exception is the shave biopsy in which dermal distention is, in fact, desirable to ensure adequate specimen collection.

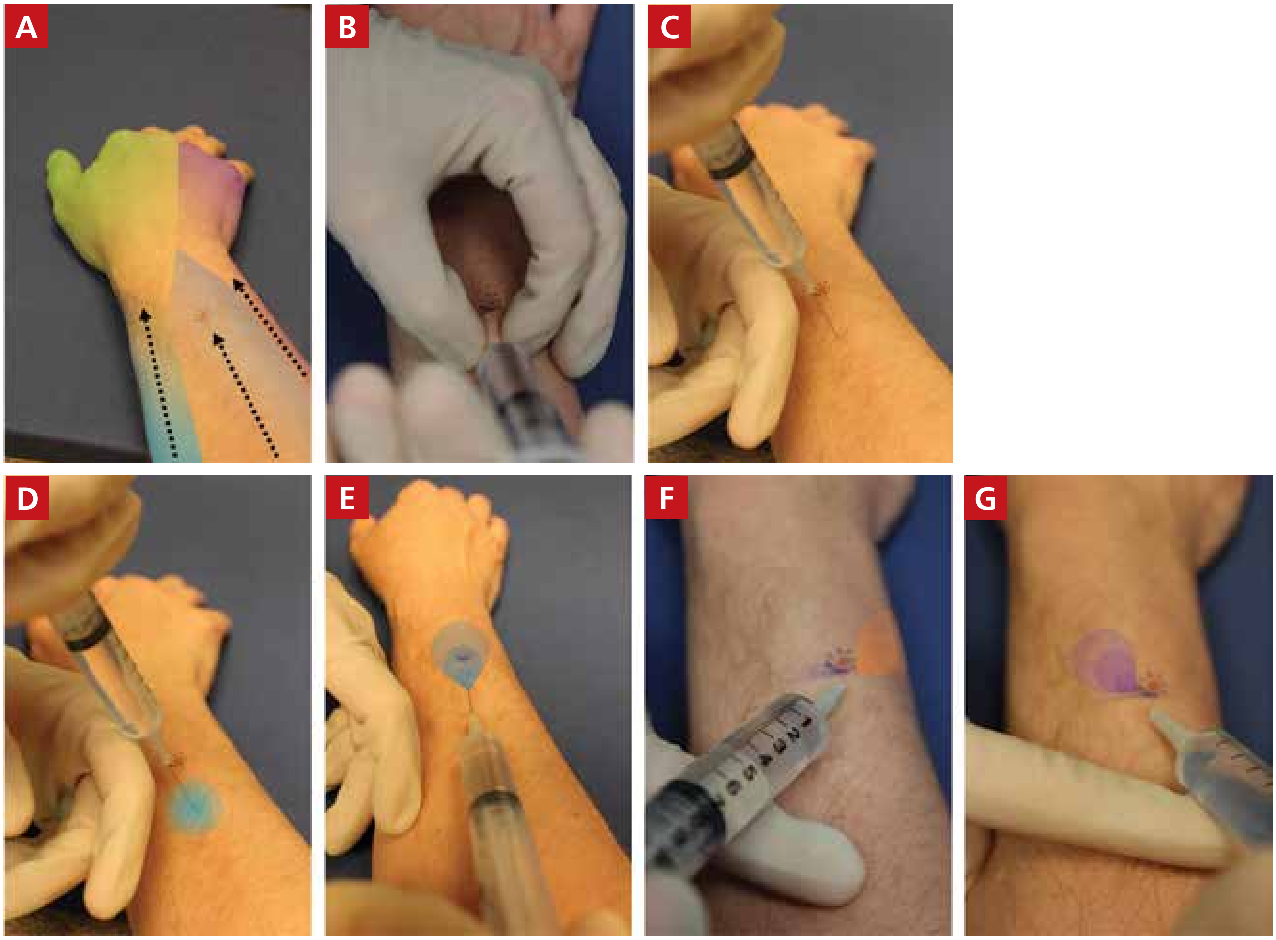
Other methods of pain reduction should still be employed. In the setting of traumatic wounds when a laceration is present, injection into the subcutaneous fat through the wound is easy and associated with less pain than injection through intact skin.[47]

Speed of injection. Rapid injection of anesthesia is associated with worse injection site pain and decreased patient satisfaction.[48-50] Slowing the rate of injection causes less rapid distention of the dermis and subcutaneous space, resulting in decreased pain afferent activation and increased time for nerve blockade. Its importance is underscored by a prospective, randomized trial that compared rate of administration with buffering of local anesthetics and demonstrated that slow

Warming and buffering solution provide a synergistic effect on pain reduction.

FIGURE 1

Field block for excisional biopsy



PHOTOS COURTESY OF BRENT DEGEORGE, MD, PhD, AND ROBERTO MARTINEZ, MD, THE UNIVERSITY OF VIRGINIA DEPARTMENT OF PLASTIC SURGERY

To administer a local anesthesia injection for an excisional biopsy procedure, first consider the innervation of the area of planned dissection. The direction of innervation is indicated by the hashed black arrows (**A**). Mark the area of planned dissection in ink. Select the initial injection site at a point most proximal to the area of planned dissection. Perform counter-stimulation and administer pressure simultaneous to initial needle entry (**B**). Make sure initial needle entry is perpendicular to the skin surface (**C**). Raise a subcutaneous wheal (swelling-caused injection of fluid) proximal to the area of planned dissection without moving the needle (**D**). Maintain a wheal of local anesthetic ahead of the needle (**E**). Infiltrate the area of planned dissection, advancing the needle slowly through previously anesthetized skin without having the needle advance ahead of the front of local anesthetic (**F,G**).

administration impacted patient-perceived pain more than buffering solution.[51]

Needle stabilization. Following perpendicular entry of the needle into the area of planned infiltration, deliver 0.5 mL of local anesthetic into the subcutaneous space without movement of the needle tip.[52] With a stabilized needle tip, pain associated with initial needle entry is no longer perceived within 15 to 30 seconds.

It is paramount to stabilize both the syringe and the area of infiltration to prevent patient movement from causing iatrogenic injury or the need for multiple needlesticks. This can be accomplished by maintaining the dominant hand in a position to inject (ie, thumb on the plunger).

Needle reinsertion. Once subcutaneous swelling of local anesthesia is obtained, the needle may be slowly advanced, maintaining a palpable subcutaneous wavefront of local anesthesia ahead of the needle tip as it moves proximally to distally.[2,52] Any reinsertion of the needle should be through previously anesthetized skin; this blockade is assessed by the presence of palpable tumescence and blanching (from the epinephrine effect).[53]

An example of the application of these injection pearls is demonstrated in the administration of a digital nerve block in **FIGURE 2**.[54,55] With the use of the techniques outlined here, the patient ideally experiences only the initial needle entry and is comfortable for the remainder of the procedure. JFP

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FIGURE 2

Digital nerve block

For a digital nerve block, use the volar single-injection technique because it is associated with reduced procedural pain and improved patient satisfaction.[55] Prepare and warm the solution. Pad the patient's hand with a folded towel behind the wrist for support, and place the hand in full supination. Select the entry site in the midline of the finger just proximal to the palmar digital crease. Assess distal sensation prior to initiating the procedure.

Stabilize the syringe, insert the needle subcutaneously perpendicular to the hand, and deliver 2 to 3 mL of local anesthetic slowly over the course of 2 minutes without moving the needle. For procedures on the nail unit, administer an additional 1 mL of local anesthetic subcutaneously overlying the middle phalanx dorsally to provide additional blockade of the dorsal sensory nerve branches. The duration of anesthesia following digital nerve blockade is 10.4 hours for lidocaine with epinephrine and 4.9 hours for plain lidocaine, which is more than sufficient for office-based procedures.[56] Although it is less well discussed in the literature, the same principles could apply to anesthesia of the toes for removal of ingrown nails.

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