Quality Resource Guide

Contemporary Local Anesthetics in Dental Practice

Author Acknowledgements

STANLEY F. MALAMED, DDS

Dentist Anesthesiologist
Emeritus Professor of Dentistry
Herman Ostrow School of Dentistry of U.S.C.
Los Angeles, California

Dr. Malamed is a Diplomate, American Dental. Board of Anesthesiology and a consultant to Septodont, NA and OnPharma.

Educational Objectives

On completion of this unit, the learner should be able to:

1. Name the five injectable amide-local anesthetics currently available in North America.
2. Discuss the difference between the metabolism of ester- and amide-type local anesthetics.
3. Define "*target organ*" and name the target organs for local anesthetics.
4. Describe the initial signs and symptoms of local anesthetic systemic toxicity.
5. List the benefits associated with buffering local anesthetic solutions.
6. Discuss the efficacy of phentolamine mesylate in decreasing the duration of soft tissue anesthesia.
7. Discuss the clinical characteristics of articaine HCL compared to those of other amide local anesthetics.

The following commentary highlights fundamental and commonly accepted practices on the subject matter. The information is intended as a general overview and is for educational purposes only. This information does not constitute legal advice, which can only be provided by an attorney.

© 2021 MetLife Services and Solutions, LLC. All materials subject to this copyright may be photocopied for the noncommercial purpose of scientific or educational advancement.

Originally published January 2021. Expiration date: January 2024.

The content of this Guide is subject to change as new scientific information becomes available.

MetLife designates this activity for **1.0 continuing education credits** for the review of this Quality Resource Guide and successful completion of the post test.

ADA C·E·R·P® | Continuing Education Recognition Program

MetLife is an ADA CERP Recognized Provider.
Accepted Program Provider FAGD/MAGD Credit **11/01/16 - 06/30/21.**

ADA CERP is a service of the American Dental Association to assist dental professionals in identifying quality providers of continuing dental education. ADA CERP does not approve or endorse individual courses or instructors, nor does it imply acceptance of credit hours by boards of dentistry.

Address comments or questions to:

DentalQuality@metlife.com

MetLife Dental Continuing Education
501 US Hwy 22, Area 3D-309B
Bridgewater, NJ 08807

Cancellation/Refund Policy:
Any participant who is not 100% satisfied with this course can request a full refund by contacting us.

Concerns or complaints about a CE provider may be directed to the provider or to ADA CERP at www.ada.org/goto/cerp.

Introduction

Local anesthetics (LAs) are the major drug group preventing a propagated nociceptive impulse from reaching the brain where it would be interpreted as pain. They form the backbone of pain control techniques in dentistry. Deposited close to a nerve they will – in virtually all situations – provide profound anesthesia, allowing dental procedures to be completed painlessly.

Within the category of 'healthcare providers,' dentistry is the prime user of LAs. More than 300 million dental LA cartridges are administered annually In the United States;[1] in Canada between 30 and 40 million.[2] Worldwide, it is conservatively estimated that 1.96 billion dental cartridges are administered annually.[3] Additionally, in many countries (such as India and China) large volumes of LA injections are administered from multidose vials. Used properly, LAs represent the safest and most effective drugs for the prevention and management of peri- and post-operative pain.

This Quality Resource Guide reviews the evolution and clinical characteristics of the five LAs available for dental use in North America; discusses the prevention, recognition, and management of local anesthetic systemic toxicity (*LAST*); assesses several significant recent advancements in dental LAs, including: the LA 'ON switch' – buffering; the LA 'OFF switch' – phentolamine mesylate (PM); and analyzes articaine, the most recent addition to the dental LA armamentarium.

The Drugs

The history of anesthesia starts with Horace Wells, a Connecticut dentist, who, in 1844, introduced nitrous oxide anesthesia, followed in 1846 with the introduction of ether by William TG Morton, DDS, MD.[4] In 1860, the chemist Albert Niemann isolated cocaine – the active ingredient in coca leaves[5] but it wasn't until 1884 that a Viennese ophthalmologist, Carl Koller, working with Sigmund Freud, performed the first operation using cocaine – using it as a topical anesthetic on a patient with glaucoma.[6] Later that same year, the American surgeon William Stewart Halsted, MD was the first to inject a LA – cocaine. The injection was the inferior alveolar nerve block (IANB).[7]

Amino-ester local anesthetics – the 'esters'

Local anesthetics became quite popular within both medicine and dentistry, but it was dentistry where their use became commonplace. LAs began to be synthesized (cocaine is the only naturally occurring LA) including procaine (1906) and tetracaine (1933). These LAs and other similar compounds belong to the chemical classification of amino-esters (commonly called 'esters'). (**Figure 1**)

It wasn't until 1925 that the dental cartridge was introduced, under the trademarked name, Carpule®.[8] The trademark expired in 2006.[9] Carpules no longer exist.

Amino-amide local anesthetics – the 'amides'

Astra Pharmaceuticals, in 1948, introduced the first amino-amide ('amides') LA – lidocaine (Xylocaine®). Demonstratively more effective than the esters, lidocaine quickly became, and remains, the most used LA in dentistry, both in the USA and worldwide. Other amides were later introduced, providing dentistry with an armamentarium of safe and effective LAs in various formulations (articaine, bupivacaine, mepivacaine, and prilocaine) with a range of durations of action.

In the dental profession today – almost worldwide – amides have replaced esters as the drugs of choice for pain control during dental procedures. The only ester used to any degree is benzocaine, the most common active ingredient in topical anesthetics.

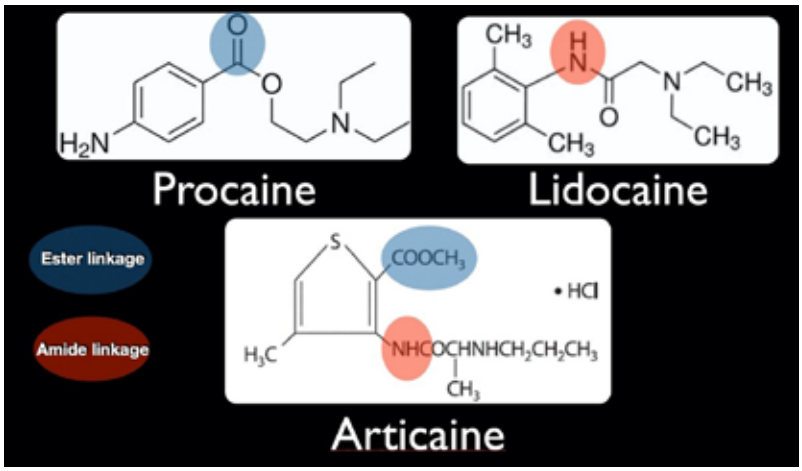
The addition of a vasoconstrictor to the LA solution increases both the depth and duration of anesthesia. Additionally, and perhaps most importantly, epinephrine decreases the plasma level of the LA, increasing the drug's safety. With these benefits comes a significant increase in the duration of soft tissue anesthesia.

Metabolism of local anesthetics

A significant difference between esters and amides is the pathway of their metabolic disposition (biotransformation, detoxification). It is important to note that metabolism has no relevance to the clinical duration of a LA (nor any drug). The therapeutic action of a drug ends as it is *redistributed* from an area of high concentration at its site of action (a nerve for LAs) to other areas in the body where it does not exert a clinical effect.

The clinical action of the LA (anesthesia) is noted as long as it remains within the affected nerve in a concentration high enough to block propagated nerve impulses. Just as a LA works by diffusing into a nerve from its site of deposition, a LA stops working by diffusing out of the nerve into the cardiovascular system (CVS) – initially the capillaries. When the LA concentration in the nerve falls below a threshold level, propagated pain impulses may again reach the brain where they are interpreted as pain.

Figure 1 - Chemical formulas of ester (procaine); amide (lidocaine); and articaine



When LA enters the CVS it is still pharmacologically active. As the blood level of LA increases, it exerts clinical actions in its *target organs* (an area in the body where a drug exerts clinical actions). LA target organs are (1) the brain (CNS); and (2) myocardium, both of which LAs *depress*. The brain is appreciably more sensitive to elevated blood levels of LA than the myocardium.

Local Anesthetic Systemic Toxicity (LAST)

Biotransformation of an ester LA into inactive chemicals occurs when it enters the CVS, being hydrolyzed by plasma esterases. What is known as elimination half-life is the time required for the blood concentration of a drug to decrease by 50%. At 6 half-lives, its blood concentration has decreased by 98.375% (assuming only one initial dose, ignoring any drug-drug interactions and assuming a healthy individual); a blood level below the threshold for any clinical activity. For example, the elimination half-life of procaine (Novocain®) is 6 minutes. At 6 half-lives – 36 minutes – procaine has essentially been eliminated from the body.

Biotransformation of amide LAs is more complex, occurring primarily in the liver (by hepatic microsomal enzymes). Virtually the entire metabolic process for lidocaine, mepivacaine, prilocaine and bupivacaine occurs in the liver. The elimination half-life of lidocaine is approximately 90 minutes and prilocaine's half-life is ~70 minutes.[11] Articaine, classified as an amide LA is, in actuality, a hybrid ester–amide molecule (**Figure 1**). About 90% to 95% of articaine's metabolism occurs by the action of plasma esterases.[12] Articaine's half-life is 20 to 27 minutes in both adult and geriatric patients,[12,13] and 18.5 to 23.6 minutes in a pediatric patient.[14] **Table 2** compares the elimination half-lives of ester and amide local anesthetics.

Local anesthetic systemic toxicity (*LAST*)

LAs are extremely safe and effective drugs when used properly. However, all-too-many instances of serious adverse events associated with their administration are noted, both in professional literature[15,16] and the lay media.[17] Chicka *et al*., in a review of 17 adverse anesthesia events, noted that 41% involved *LAST*. The average age of the affected patient was 3.6 years.[15] Gaiser, *et al.* observed that 36% of 14 dental office deaths in the United Kingdom involved *LAST*.[16] In Italy, Minoli *et al* reported on 36 fatal events in dental offices; 47% had a temporal relationship between injection of LA and the death of the patient.[17]

Table 1 - Local anesthetic formulations available in North America (March 2021)[10]

Drug (formulations)	Duration*	Mgs/cartridge+	MRD# mg/kg (absolute maximum mg)
Articaine 4% + epi 1:100,000 4% + epi 1:200,000	 Intermediate Intermediate	 72 72	7.0 (no absolute maximum listed in USA)
Bupivacaine 0.5% + epi 1:200,000	Long	9	No mg/kg listed in USA (90); Canada 2.0 (200)
Lidocaine 2% + epi 1: 50,000 2% + epi 1:100,000	 Intermediate Intermediate	 36 36	7.0 (500)
Mepivacaine 3% 2% + levo 1:20,000	 Short Intermediate	 54 36	6.6 (400)
Prilocaine 4% 4% + epi 1:200,000	 Short Intermediate	 72 72	8.0 (600)

* Short: pulpal anesthesia ~30 minutes; Intermediate: ~60 minutes; Long: >90 minutes

\+ Dental cartridges contain approximately 1.76 mL of local anesthetic solution,[10] though some are labeled as: "minimum content of each cartridge 1.7 mL" while others are labeled: "minimum content of each cartridge 1.8 mL"

\# Maximum recommended dose, United States Food & Drug Administration.

epi: epinephrine

levo: levonordefrin

Table 2 - Elimination half-lives of local anesthetics

Drug	Half-life (minutes)	6x half-life (minutes)
Procaine Chloroprocaine	6	36
Tetracaine	20	120
Articaine	27	162
Cocaine	42	252
Prilocaine	~70	~490
Lidocaine	~90	~540
Mepivacaine	~90	~540
Bupivacaine	~210	~1,260
Ester – blue, Amide – yellow, Articaine - green		

LAST – Prevention

The two most common etiologies of *LAST* are (1) rapid intravascular administration, and (2) administration of an excessive dose of LA. One cartridge of any LA formulation administered intravascularly in less than 15 seconds produces a rapid and significant elevation in LA blood level, leading to the immediate onset of tonic-clonic seizure activity and/or cardiovascular collapse.

LAST from intravascular administration can almost always be prevented by:

1) performing two (2) aspiration tests before deposition of the LA, rotating the needle bevel ~45 degrees between the tests (if negative x2 the likelihood of intravascular injection is essentially zero);

2) slow administration of LA. The ideal rate of administration of any injectable drug is 1 mL/minute. As many dentists admit to injecting LA more rapidly,[18] it is *recommended* that a 1.8 mL cartridge be administered over at least one minute.[19]

However, the most common *LAST* scenario involves administering an excessive LA dose to a child weighing less than 30 kg.[15,20,21] (see **Table 3**) There exists no rationale for the administration of LA in all four quadrants at one time in lighter weight patients. Additionally, the volume of LA required for pain control in younger children is but a fraction of that in an adult.[22]

Considering that *all* injectable LAs are inherently vasodilators, it is recommended that whenever treating a patient weighing less than 30 kg in more than one quadrant, the LA should contain a vasoconstrictor. Vasoconstrictors increase the depth and duration of pain control, but more importantly, they produce a lower LA blood level, increasing the drug's safety.[22]

As de Jong stated in his classic textbook on local anesthesia: *"the brain responds to the concentration of local anesthetic delivered to it by the bloodstream and cares not at all how the drug got into the blood."*[23]

LAST – Recognition

As LA blood level increases in the brain, clinical signs and symptoms (S&S) begin to be observed. **Figure 2** illustrates the progression noted when an overly large dose of a 'plain' LA (3% mepivacaine or 4% prilocaine) has been administered 'correctly' – not intravascularly. In most instances of *LAST*, initial S&S involve the CNS and include a metallic taste, dizziness, tinnitus ('ringing' in the ears), and visual disturbances. Where an excessively large dose of a 'plain' LA has been administered, its seizure threshold will be exceeded approximately ten minutes following its administration. Tonic-clonic seizure activity is commonly observed with *LAST*.

Symptoms associated with myocardial depression usually appear after seizure activity has been noted and most commonly when the LA has been administered directly into the CVS. S&S of *LAST* following intravascular administration appear within seconds; starting with seizure activity, oftentimes leading rapidly to ventricular dysrhythmias (ventricular fibrillation, cardiac arrest).

LAST – Management

Management of *LAST* follows the **P→C→A→B→D** protocol* for all medical emergencies.[24] Emergency medical services (911) should be summoned immediately.

* *P=Positioning; C=Circulation; A=Airway; B=Breathing; D=Definitive Care*

Figure 2 - The usual sequence of signs and symptoms of *LAST* following slow, steady increase in LA blood level

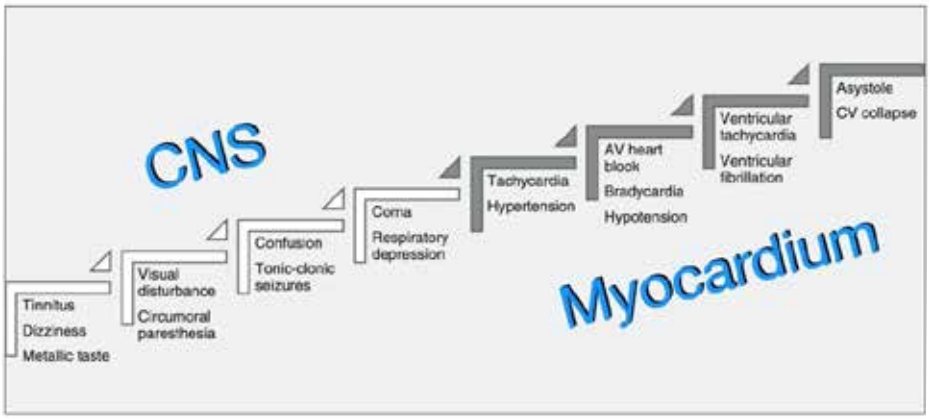


Table 3 - Factors adding to increased risk of *LAST* in younger patients

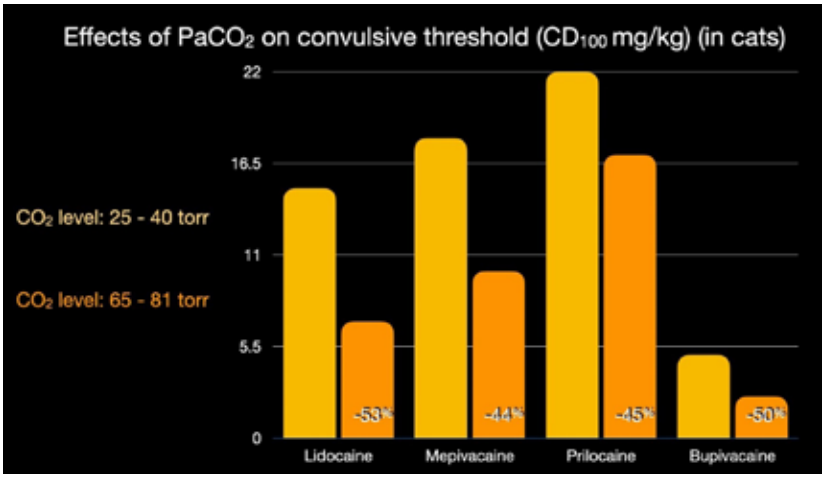
The majority of local anesthetic overdose cases involve the following:

1. Patient weight less than 30 kg
2. Treatment plan – all four quadrants treated with local anesthetic at one visit
3. Local anesthetic administered is "plain" (no vasoconstrictor)
4. Full cartridge (1.8 mL) administered with each injection
5. Local anesthetic administered to all four quadrants at one time
6. Exceeding the maximum dose based on the patient's body weight

In the presence of seizure activity, preventing injury is paramount. The seizure ceases when the LA has been redistributed and its blood level in the brain falls below its seizure threshold. In most instances – when a patent airway is maintained (*e.g.* head-tilt, chin-lift) – seizures last for but 1 minute.[24] The absolute importance of airway maintenance during and following the seizure is illustrated in **Figure 3**. Absent a patent airway the LA seizure threshold decreases significantly – 53% for lidocaine – increasing both the duration and intensity of the seizure.

Data indicate that if LA-induced seizures are brief and well managed, no permanent neurological or behavioral sequelae will occur.[25]

Figure 3 - Effects of hypercarbia (elevated CO_2) on the convulsive threshold of local anesthetics



Recent Advances in Dental Local Anesthesia

Buffering local anesthetic solutions – the local anesthetic 'ON SWITCH'

LAs containing a vasoconstrictor are highly acidic – a pH ranging from 3.0 to 4.0.[26] The pH decreases rapidly within the first 3 months of manufacture, eventually plateauing over the 24-month shelf life of the cartridge. Injection of this acidic solution can be associated with a 'stinging' or 'burning' sensation. The addition of a defined volume of 8.4% sodium bicarbonate to a dental cartridge raises its pH to approximately 7.35 to 7.4, producing a more comfortable injection experience for the patient. Additional benefits of buffering include: significantly more rapid onset of pulpal anesthesia;[27] more profound anesthesia;[28] and decreased post-injection soreness.[29] Though not all assessments of buffering have demonstrated benefits, the author recommends that all LA injections be buffered.[30,31]

Phentolamine mesylate – the local anesthetic 'OFF SWITCH'

The addition of a vasoconstrictor to the LA solution increases the depth of anesthesia as well as the duration. With these benefits comes a significant increase in the duration of soft tissue anesthesia. Self-inflicted soft tissue injury – biting or chewing of the numb lip or tongue – is not uncommon in young patients,[32] as well as in developmentally disabled adults.

Phentolamine mesylate (PM), an alpha-adrenergic antagonist, injected at the end of a dental procedure, into the site of previous LA administration, significantly decreases the duration of soft tissue anesthesia.[33] Following IANB, at 60 minutes 41% of subjects receiving PM had a complete loss of anesthesia of the lip compared to 7.4% of subjects receiving placebo.[33] At 90 minutes, the results were 70.5% versus 13.1%. (**Table 4**)

Articaine hydrochloride – dentistry's newest local anesthetic

In June of 2000, the FDA approved articaine HCl (4% with 1:100,000 epinephrine) for use in the USA. Articaine has become the 2nd most used LA, both in the USA and worldwide. In 2005, articaine 4% with 1:200,000 epinephrine was FDA approved. Both formulations are categorized as intermediate duration. (**Table 1**)

Table 4 - Complete loss of anesthesia

	Upper lip		Lower lip	
Time (minutes)	Phentolamine	Control	Phentolamine	Control
30	26.7%	1.7%	17.2%	0.8%
60	59.2%	11.7%	41.0%	7.4%
90	75.0%	25.0%	70.5%	13.1%
120	88.4%	45.8%	81.1%	29.5%

A 'quality of life' drug, PM is appropriate for any patient desiring a return to 'normal' sensation rapidly – including business-people, those attending social gatherings, or lunch or dinner engagements, in addition to young children and developmentally disabled persons.

A considerable body of research has demonstrated articaine's clinical superiority to other amide LAs.[34,35] A more lipid-soluble drug, articaine provides pulpal anesthesia following buccal infiltration in the adult mandible.[10] Articaine is a hybrid molecule – both amide and ester. (**Figure 1**) As discussed above, the half-life of articaine (~27 minutes) is shorter than that of the other amide LAs (~90 minutes), conferring it with several advantages, including – in this authors opinion: decreased risk of *LAST* from the administration of higher doses of LA, thereby making it a preferred LA in lighter-weight patients,[36] pregnant and nursing patients,[37] as well as being more effective in achieving successful pain control in endodontically-involved teeth.[38]

When introduced in Canada (1985) and later in the USA (2000), there was discussion regarding a possible link between 4% LAs (articaine and prilocaine) and increased risk of paresthesia following IANB.[39] Paresthesia remains a topic of discussion, though recent laboratory research and clinical meta-analyses have concluded that articaine is as neurotoxic as other commonly used LAs, not more so.[40-42]

All LAs are neurotoxins. Paresthesia (some degree of sensory dysfunction persisting more than 24 hours following injection), albeit extremely rare, can and does occur. Reported frequencies following IANB vary considerably from 1:26,762 to 1:160,571 injections.[43] Management of paresthesia is detailed in an article by Pogrel *et al*.[43]

Summary

Local anesthetics form the backbone of pain control techniques in dentistry. Used properly, local anesthetics are the safest and most effective drugs for the prevention and management of peri- and post-operative pain. Care must be taken whenever LAs are used to ensure their proper delivery and to avoid excessive dosing. The ability to prevent, recognize and effectively manage any adverse events associated with their administration is essential to their safe use. The availability of buffering (the LA 'on-switch') and phentolamine mesylate (the LA 'off-switch') greatly enhance patient comfort both during and after dental procedures, as well as increasing the likelihood of successful pain control being achieved.

References

1. Communication with Septodont NA. Lancaster, PA, 17601. May 2016.
2. Communication with Novocol Pharma, Cambridge, Ontario, Canada, N1R 6X3. December 2020
3. Communication with Septodont Holding. Saint Maur des Fosses Cedex, France. May 2017
4. Wells H: A history of the discovery of the application of nitrous oxide gas, ether and other vapors to surgical operations. Hartford, J Gaylord Wells, 1847, pp 5–14
5. Niemann A: Ueber eine neue organische Base in den Cocablättern. Arch Pharm 1860; 153:129–55, 291–308
6. Koller C: On the use of cocaine for producing anaesthesia on the eye. Lancet 1884; 2:990–992
7. Olch PD, William S: Halsted and local anesthesia: contributions and complications. Anesthesiology 1975;42:479–486
8. United States Patent Office. 'CARPULE.' Cook Laboratories, Inc. Chicago, IL. 4 August 1925
9. Sterling Drug Inc. Legal Department, 90 Park Avenue, New York, NY 10016. 6 May 2006
10. Robertson D, Nusstein J, Reader A, Beck M, McCartney M. The anesthetic efficacy of articaine in buccal infiltration of mandibular posterior teeth. J Am Dent Assoc. 2007;138(8):1104-1112.
11. Prilocaine drug monograph. ClinjicalKey. www.ClinicalKey.com. 28 February 2010. Accessed 13 December 2020.
12. Oertel R, Rahn R, Kirch W. Clinical pharmacokinetics of articaine. Clin Pharmacokinet 1997;33(6):417-425
13. Oertel R, Ebert U, Rahn R, Kirch W. The effect of age on pharmacokinetics of the local anesthetic drug articaine. Reg Anesth Pain Med. 1999 Nov-Dec;24(6):524-528.
14. Jakobs W, Ladwig B, Cichon P, Ortel R, Kirch W. Serum levels of articaine 2% and 4% in children. Anesth Prog. 1995;42(3-4):113-115.
15. Chicka MC, Dembo JB, et al. Adverse events during pediatric dental anesthesia and sedation: a review of closed malpractice insurance claims. Pediatr Dent 2012;34(3):231-238
16. Gaiser M, Kirsch J, Mutzbauer TS. Using non-expert online reports to enhance expert knowledge about causes of death in dental offices reported in scientific publications qualitative and quantitative content analysis and search engine analysis. J Med Internet Res 2020;22(4):e15304
17. Minoli M, Zechini G, et al. Dental deaths in Italy as reported by online press articles. Oral Dis 2020;26(5):858-864
18. Malamed SF. Drug overdose reactions, in Handbook of medical emergencies in the dental office. Malamed SF. 8th edition, 2021. Elsevier, St. Louis, MO.
19. Techniques for delivery of local anaesthesia, in Local anaesthesia in dentistry. Robinson PD, Pitt Ford TR, McDonald F, editors. 2000. Wright Reed Elsevier. Oxford. page 28.
20. Malamed SF. Morbidity, mortality and local anesthesia. Prim Dent Care 1999;6(1):11-15.
21. Hersh EV, Helpin ML, Evans OB. Local anesthetic mortality: report of a case. ASDC J Dent Child 1991;58(6):489-491.
22. Jones JE, Dean JA. Local anesthesia and pain control for the child and adolescent, in McDonald and Avery's Dentistry for the Child and Adolescent. 10th edition. Dean JA, editor. 2016. Elsevier, St. Louis.
23. Cannell H, Walters H, Beckett AH, Saunders A. Circulating levels of lignocaine after peri-oral injections. Br Dent J. 1975;138(3):87-93.
24. de Jong RH. Central nervous system effects. in Local Anesthetics. Mosby-Year Book, Inc. St. Louis, MO. 1994. Page 276
25. Malamed SF. Systemic complications, in Handbook of Local Anesthesia, Malamed SF. 7th edition, 2020. Elsevier, St. Louis, MO.
26. Feldman HS, Arthur GR, Pitkanen M, et al. treatment of acute systemic toxicity after rapid intravenous injection of ropivacaine and bupivacaine in the conscious dog. Anaesth Analg 1991;73:373-384.
27. Communication with Novocol Pharma, Cambridge, Ontario, Canada, N1R 6X3. March 24, 2020.
28. Whitcomb M, Drum M, Reader A, Nusstein J, Beck M. A prospective, randomized, double-blind study of the anesthetic efficacy of sodium bicarbonate buffered 2% lidocaine with 1:100,000 epinephrine in inferior alveolar nerve blocks. Anesth Prog. 2010;57(2):59-66.
29. Kattan S, Lee SM, Hersh EV, Karabucak B. Do buffered local anesthetics provide more successful anesthesia than nonbuffered solutions in patients with pulpally involved teeth requiring dental therapy?: A systematic review. J Am Dent Assoc. 2019;150(3):165-177.
30. Malamed SF, Tavana S, Falkel M. Faster onset and more comfortable injection with alkalinized 2% lidocaine with epinephrine 1:100,000. Compend Contin Educ Dent. 2013 Feb;34 Spec No 1:10-20.
31. Falkel M, Malamed SF: Buffering: the key to more effective and comfortable local anesthesia, Inside Dentistry 2020;16:CE eBook 11:1-10 (May)
32. Malamed SF, Falkel M. Buffered local anesthetics: The importance of pH and CO_2. SAAD 2013;29:9-17.
33. College C, Feigal R, Wandera A, Strange M. Bilateral versus unilateral mandibular block anesthesia in a pediatric population. Pediatr Dent. 2000;22(6):453-457.
34. Hersh EV, Lindemeyer R, Berg JH, Casamassimo PS, et al, Group PS. Phase four, randomized, double-blinded, controlled trial of phentolamine mesylate in two- to five-year-old dental patients. Pediatr Dent. 2017;39(1):39-45.
35. Katyal V. The efficacy and safety of articaine versus lignocaine in dental treatments: A meta-analysis. J Dent. 2010;38(4):307–317.
36. Yapp KE, Hopcraft MS, Parashos P. Articaine: A review of the literature. Br Dent J. 2011;210(7):323–329.
37. Taneja S, Singh A, Jain A. Anesthetic Effectiveness of Articaine and Lidocaine in Pediatric Patients During Dental Procedures: A Systematic Review and Meta-Analysis. Pediatr Dent. 2020;42(4):273-281.
38. American Society of Anesthesiologists, Committee on Obstetric Anesthesia. Statement on resuming breastfeeding after anesthesia. ASA House of Delegates, Approved 23 Oct 2019. Amer Soc Anesthesiol., Schaumburg, IL, Oct 2019.
39. Peters MC, Botero TM. In patients with symptomatic irreversible pulpitis, articaine is 3.6 times more efficacious than lidocaine in achieving anesthetic success when used for supplementary infiltration after mandibular block anesthesia. J. evid-based dent pract. 2017;17(2):99–101.
40. Haas DA, Lennon D. A 21-year retrospective study of reports of paresthesia following local administration. J Can Dent Assoc. 1995;61(4):319–320, 323–326, 329–330.
41. Malet A, Faure MO, Deletage N, Pereira B, et al. The comparative cytotoxic effects of different local anesthetics on a human neuroblastoma cell line. Anesth Analg. 2015;120(3):589–596.
42. Baroni DB, Franz-Montan M, Cogo K, Berto LA, et al. Effect of articaine on mental nerve anterior portion: histological analysis in rats. Acta Odontol Scand 2012;71(1):82-87.
43. Albalawi F, Lim JC, DiRenzo KV, Hersh EV, Mitchell CH. Effects of Lidocaine and Articaine on Neuronal Survival and Recovery. Anesth Prog. 2018;65(2):82-88.

POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the "Online Exam." We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

(1.0 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. **Which of the following is/are target organs for local anesthetics?**
   - **A. Lungs**
   - **B. Myocardium**
   - **C. Liver**
   - **D. CNS**

   a. A only
   b. D only
   c. B and C only
   d. A and B only
   e. B and D only

2. **Which of the following local anesthetics has the <u>LONGEST</u> duration of pulpal anesthesia?**
   a. Lidocaine HCl 2% with epinephrine.
   b. Bupivacaine HCl 0.5% with epinephrine.
   c. Mepivacaine HCl 3% via infiltration.
   d. Prilocaine HCl 4% via nerve block.

3. **Which of the following local anesthetics has the <u>SHORTEST</u> duration of pulpal anesthesia?**
   a. Lidocaine HCl 2% with epinephrine 1:50,000.
   b. Bupivacaine HCl 0.5% with epinephrine 1:200,000.
   c. Mepivacaine HCl 3% via infiltration.
   d. Prilocaine HCl 4% via nerve block.

4. **The process by which the clinical action of local anesthetics ceases is:**
   a. Biotransformation
   b. Redistribution
   c. Detoxification
   d. Amniocentesis
   e. Metabolism

5. **A primary concern when administering local anesthetics to a 20 Kg child is:**
   a. Self-inflicted soft tissue trauma.
   b. Allergy to the local anesthetic.
   c. Allergy to the vasoconstrictor.
   d. Local anesthetic systemic toxicity.

6. **What is the absolute MRD for lidocaine?**
   a. 300 mg
   b. 400 mg
   c. 500 mg
   d. 600 mg
   e. No MRD is listed for lidocaine

7. **Tonic-clonic seizures occur when the cerebral blood level of the local anesthetic is "too high". Tonic-clonic seizures resulting from local anesthetics are the result of the CNS-stimulant actions of the local anesthetic.**
   a. Both statements are TRUE
   b. Both statements are FALSE
   c. 1st statement is TRUE; 2nd statement is FALSE
   d. 1st statement is FALSE; 2nd statement is TRUE

8. **What is the effect of increased CO_2 blood levels on the duration of a local anesthetic-induced generalized tonic-clonic seizure?**
   a. Changes in CO_2 levels have NO effect on local anesthetic-induced seizures.
   b. Increased CO_2 levels will shorten the duration of a local anesthetic-induced seizure.
   c. Increased CO_2 levels will prolong the duration of a local anesthetic-induced seizure.

9. **Which of the following local anesthetics is a hybrid ester-amide molecule?**
   a. articaine HCl
   b. bupivacaine HCl
   c. lidocaine HCl
   d. mepivacaine HCl
   e. procaine HCl

10. **Which of the following has been shown to significantly decrease the duration of soft tissue anesthesia when administered at the end of a dental procedure?**
    a. alphaprodine
    b. phentolamine mesylate
    c. paracetamol
    d. midazolam

Registration/Certification Information (Necessary for proper certification)

Name (Last, First, Middle Initial): _____

PLEASE PRINT CLEARLY

Street Address: _____ Suite/Apt. Number _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

Date of Birth: _____ Email: _____

State(s) of Licensure: _____ License Number(s): _____

Preferred Dentist Program ID Number: _____ ☐ Check Box If Not A PDP Member

AGD Mastership: ☐ Yes ☐ No

AGD Fellowship: ☐ Yes ☐ No Date: _____

Please Check One: ☐ General Practitioner ☐ Specialist ☐ Dental Hygienist ☐ Other

FOR OFFICE USE ONLY

Evaluation - Contemporary Local Anesthetics in Dental Practice 1st Edition

Providing dentists with the opportunity for continuing dental education is an essential part of MetLife's commitment to helping dentists improve the oral health of their patients through education. You can help in this effort by providing feedback regarding the continuing education offering you have just completed.

Please respond to the statements below by checking the appropriate box, using the scale on the right.

	1 = POOR 1	2	3	4	5 = Excellent 5	
1. How well did this course meet its stated educational objectives?	☐	☐	☐	☐	☐	
2. How would you rate the quality of the content?	☐	☐	☐	☐	☐	
3. Please rate the effectiveness of the author.	☐	☐	☐	☐	☐	
4. Please rate the written materials and visual aids used.	☐	☐	☐	☐	☐	
5. The use of evidence-based dentistry on the topic when applicable.	☐	☐	☐	☐	☐	☐ N/A
6. How relevant was the course material to your practice?	☐	☐	☐	☐	☐	
7. The extent to which the course enhanced your current knowledge or skill?	☐	☐	☐	☐	☐	
8. The level to which your personal objectives were satisfied.	☐	☐	☐	☐	☐	
9. Please rate the administrative arrangements for this course.	☐	☐	☐	☐	☐	

10. How likely are you to recommend MetLife's CE program to a friend or colleague? *(please circle one number below:)*

10	9	8	7	6	5	4	3	2	1	0
extremely likely					neutral					not likely at all

What is the primary reason for your 0-10 recommendation rating above?

11. Please identify future topics that you would like to see:

Thank you for your time and feedback.

MetLife

To complete the program traditionally, please mail your post test and registration/evaluation form to:
MetLife Dental Quality Initiatives Program | 501 US Highway 22 | Bridgewater, NJ 08807