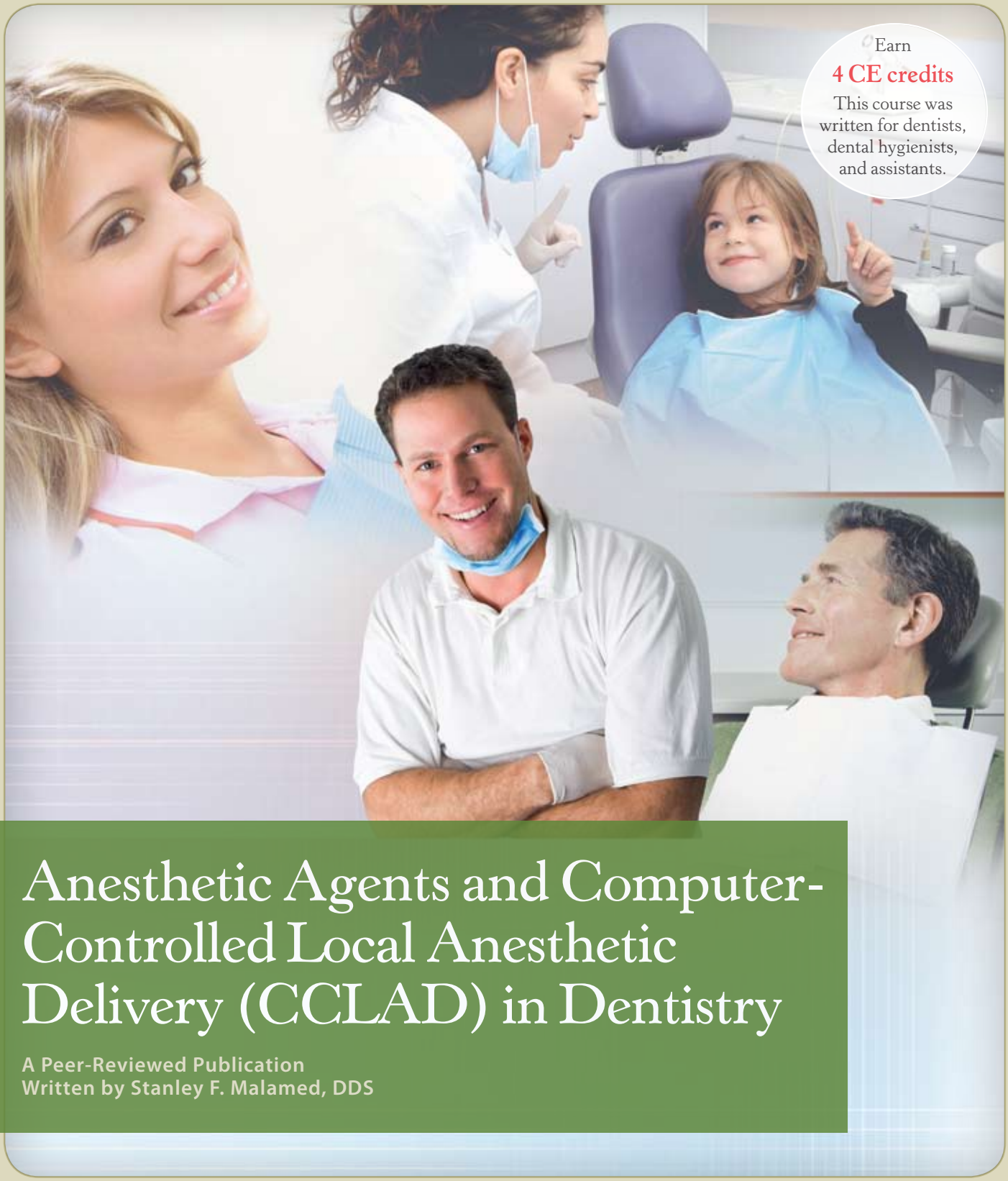

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Anesthetic Agents and Computer-Controlled Local Anesthetic Delivery (CCLAD) in Dentistry

A Peer-Reviewed Publication
Written by Stanley F. Malamed, DDS

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Educational Objectives

Upon completion of this course, the clinician will be able to do the following:

1. Know the types of local anesthetics that have been introduced to dentistry, as well as the disadvantages of the earliest local anesthetic agents
2. Understand the disadvantages associated with local anesthetics from the patient's perspective, as well as the topical anesthetic agents available and their uses
3. Know and discuss the use of computer-controlled local anesthetic delivery (CCLAD) systems
4. Know the types of injections that have recently been introduced and the adjunctive role of CCLAD for these techniques

Abstract

The local anesthetic drugs presently available and used in dentistry represent the safest and most effective drugs in all of medicine for the prevention and management of pain. The dental profession purchased in excess of 300 million local anesthetic cartridges in the United States in 2006, making local anesthetics the most-used drugs in the dental profession. One drawback associated with intraoral local anesthesia is patients' fear of injections and the perception that these are painful. Recent advances have resulted in the use of computer-controlled local anesthetic delivery vehicles to regulate the delivery and rate of flow of local anesthetics at the injection site, lessening potential discomfort associated with injections. New injection techniques that provide reliable anesthesia have also been introduced, and depending on the technique used and area of anesthesia necessary, they do not result in undesired extraoral soft tissue anesthesia. These new injection techniques have been aided by the use of computer-controlled local anesthetic delivery systems.

Introduction

Dental treatment has long been associated, in the mind of the patient, with pain. Indeed, fear of pain is one of the most significant factors deterring adults from receiving non-emergency dental care, even more so than the monetary cost of treatment.

The dental profession can take pride in its role in leading the development of the art and science of anesthesia. Dr. Horace Wells, a Connecticut dentist, became the first person to use anesthesia for therapeutic reasons when he received 100% nitrous oxide (N_2O) in December 1844, prior to the extraction of a molar. Dr. Wells has received recognition as the founder of anesthesia. Shortly after the introduction of N_2O, other more potent inhalation agents, namely ether and chloroform, entered into use. This permitted medical and dental surgical procedures to be performed painlessly under general anesthesia instead of painfully with nothing. John Snow (1813–1858) subsequently advanced the science of anesthesiology when he administered chloroform as a sedative to Queen Victoria to ease the pain of childbirth during delivery of the last two of her nine children, Leopold in 1853 and Beatrice in 1857.

Local Anesthetics

Carl Koller (1857–1944), an Austrian ophthalmologist, demonstrated the effect of cocaine as a local anesthetic for eye surgery in 1884. Koller instilled drops of cocaine onto the surface of the eye, providing topical anesthesia. For the first time, a patient was able to undergo a surgical procedure awake and without pain. Later the same year, in Baltimore, Maryland, a surgeon, William Halstead (1852–1922), administered an injection of cocaine (with epinephrine) via inferior alveolar nerve block for the removal of a neuroma. The Halstead approach to the inferior alveolar nerve block is still considered the "traditional" mandibular injection technique and is taught in dental schools worldwide. Cocaine, considered a "wonder drug," allowed dental and medical patients to undergo painful surgical procedures painlessly while still conscious. Its use became widespread.

Desirable anesthetic properties

A number of properties are desirable for local anesthetic agents and techniques. Efficacy, safety and biocompatibility are requirements. Other properties that are desired for an ideal agent and technique include a rapid onset, adequate duration and profundity of anesthesia, anesthesia of the targeted tissues and area only, rapid reversal, a lack of side effects and contraindications, a painless anesthetic delivery that is also unobtrusive, and a technique that is easy and has no, or a minimal, learning curve.

The amino-esters (1906–1948)

By the early 1900s, there was an increasing number of reports of patients dying following the administration of cocaine. Unbeknownst to the medical establishment at that time, cocaine, in addition to being a local anesthetic, was a potent cardiovascular stimulant capable of provoking significant cardiovascular problems.

The search began for equally effective but safer drugs. In 1898, the German chemist Alfred Einhorn synthesized procaine, which was marketed in 1906 under the trade name Novocain. Following the introduction of procaine, other amino-ester local anesthetics were introduced, including tetracaine, chloroprocaine and benzocaine. Procaine became the "gold standard," the most-used local anesthetic in the world, in both medicine and dentistry. By the 1940s, dissatisfaction with procaine was becoming common. When patients were administered procaine with epinephrine in 1:50,000 concentration, the onset of anesthesia was approximately 15 minutes, while the duration of pulpal anesthesia was only about 20 minutes. Though these methods provided anesthesia that was adequate in duration for most dental procedures in the early 1900s, the dental profession by the 1940s had changed, with appointments becoming increasingly longer. Procaine did not prove to be a consistently reliable anesthetic. Additionally, and significantly, reports of true, documented and reproducible allergy to injected esters had become more common.

The amino-amides (1948–present)

A new class of local anesthetics, the amino-amides, was introduced in Sweden in the 1940s. The Swedish chemist Nils Löfgren synthe-

sized lidocaine in 1943, and the drug was introduced into dentistry in 1948 under the trade name Xylocaine. Possessing a faster onset of action (3–5 minutes), greater reliability and, when combined with epinephrine, a significantly longer duration of action (pulpal anesthesia of about 60 minutes duration), lidocaine replaced procaine as the "gold standard" in a few short years. Allergy (true, documented, and reproducible) to the amide anesthetics, if it has ever occurred, is so infrequent as to not represent a problem in the clinical use of this valuable class of drugs.

Following lidocaine, other amides were synthesized and introduced. Mepivacaine (1956), prilocaine (1960), bupivacaine (1963) and etidocaine (1971) were marketed in dental cartridges in the United States. Articaine (USA, 2000) represents the most recent addition to the local anesthetic armamentarium in American dentistry, although it was available elsewhere prior to this. In 2006, the dental profession purchased in excess of 300 million local anesthetic cartridges in the United States, making local anesthetics the most-used drugs in the dental profession.

Table 1. The development of pain control and local anesthesia in dentistry

1840s	Nitrous oxide	Inhalation
1850s	Chloroform	Inhalation
1880s	Cocaine	Topical anesthesia
	Cocaine	Local anesthesia
1900s	Procaine	Local anesthesia
1940s	Lidocaine	Local anesthesia
1950s	Mepivacaine	Local anesthesia
1960s	Prilocaine	Local anesthesia
	Bupivacaine	Local anesthesia
1970s	Etidocaine	Local anesthesia
2000 (USA)	Articaine	Local anesthesia

Various agents used for local anesthesia are also used for topical anesthesia

The local anesthesia (LA) drugs presently available represent the safest and the most effective drugs in all of medicine for the prevention and management of pain. If a local anesthetic is deposited close to a nerve, it *will* produce anesthesia. Most analgesics and anesthetics exert their clinical action(s) on the central nervous system, modifying the patient's response to the pain impulse once it reaches the brain. LAs are the only drugs that prevent the pain impulse from actually reaching the patient's brain.

Injection Fear and Anxiety

Though LAs work to prevent pain, the perception among all too many people is that the administration of LAs is painful. Many comedians, including W.C. Fields, Bill Cosby, Mr. Bean (Rowan Atkinson) and Tim Conway, have provided laughs to their audiences when describing or demonstrating a dental injection.

Local anesthetics work, but to provide the depth of anesthesia necessary to allow for painless dental (and other surgical) procedures, they must be injected. This is the problem for patients. Not the cartridge, not the syringe, but the needle. There is fear that the needle will hurt as it enters into the oral mucous membrane to deliver the local anesthetic drug. Compared with needles commonly used in the administration of drugs by the medical profession (16-,18- or 20-gauge), dental needles are quite small, usually 25-, 27- or 30-gauge. Unfortunately, intraoral injections are administered into a region of the body that is richly innervated in addition to being a psychologically important area for many people.

Clinical studies have shown that the needle gauges used in dentistry produce considerably less pain than those gauges used in medicine.[1,2] Additionally, multiple studies have demonstrated that the perception of needle-stick pain from 25-, 27- and 30-gauge needles is indistinguishable.[3-5] Despite these findings, some dentists persist in using thinner, shorter and more fragile 30-gauge short and 30-gauge ultrashort needles for dental intraoral injections under the misguided impression that they do not hurt as much as larger-gauge needles.

From the dental patient's perspective, it is the needle that most often represents the most fear-provoking part of a dental procedure. The ability of a dentist to administer a local anesthetic injection painlessly is considered by patients the most important factor when it comes to selecting a dentist.[6] With this in mind, attempts have been made over the years to eliminate the need to inject drugs in the provision of dental pain control. Nondrug techniques such as hypnosis and acupuncture have been introduced, and though they have some degree of success, neither has been readily accepted by either the dentist or the patient, remaining on the fringe of pain control techniques in dentistry.

Table 2. Judging of dentists by patients[6]

1. A dentist who gives a painless injection
2. A dentist who does not hurt you
3. Staff who are . . . kind, professional, caring, warm and helpful
4. Runs on time
5. "Doctor, that was the most thorough dental examination I've ever had."
6. Dentists who listen, allow questions, treat dumb questions with dignity
7. Patients are happy with the results
8. Prompt emergency service
9. Prompt new-patient examination appointment
10. High standard of sterilization

Ranked 1 – 10, with 1 being the most important factor

Topically Applied Local Anesthetics

Topically applied anesthetics provide a degree of anesthesia to non-keratinized tissue (e.g., oral mucous membrane) to a depth of 2 to 3 mms. This permits the initial penetration of mucous membrane to be accomplished painlessly. Application of a small amount of topical anesthetic to the injection site prior to needle penetration is an integral step in the delivery of atraumatic injections.[7] Topical anesthetics are used in concentrations that are higher than those used when the drug is injected. For example, lidocaine injectable is a 2% solution, while when used topically as a gel or ointment it is commonly 5%. Benzocaine, the most commonly used topical anesthetic, is used in a 20% concentration (gel, ointment, spray). Oraqix®, a recently introduced locally applied anesthetic gel, is a eutectic mixture of prilocaine and lidocaine, each in a 2.5% concentration. Oraqix is a periodontal gel that, when deposited as a liquid into the periodontal space with an applicator, becomes a gel at body temperature, providing anesthesia to the periodontal soft tissues and making curettage more comfortable.[8-11] Recently, flavored topical anesthetics have been produced for dentists by compounding pharmacists. Tricaine Blue, Tridocaine, TrioCaine and Profound topical are compounded topical anesthetics containing benzocaine, lidocaine and tetracaine.

As to the question of which topical is most effective, in the opinion of this author, when used properly (application of a small volume of topical to dried soft tissue for a minimum of 1 to 2 minutes), the currently available topical formulations are equally efficacious. The only topically applied local anesthetic that is markedly better is cocaine, simply because, along with it being an effective topical anesthetic, it is unique in that it possesses vasoconstricting actions. Topically applied cocaine is not used in dentistry.

Transcutaneous Electrical Nerve Stimulation (TENS) (the 1980s)

In the 1980s, the medical technique transcutaneous electrical nerve stimulation (TENS) was modified for use in dentistry as a means of obviating the need for an injection of LA for pain control – in other words, offering pain control without using needles. TENS delivers a low-frequency electrical stimulus (via electrodes) to an area of the body in which swelling (edema) has occurred (e.g., the knee).[12,13] The electrical stimulation produces skeletal muscle contraction, causing a pumping of the fluid out of the area. This helps to speed recovery from injury. With electrodes applied intraorally and the current delivered at a higher frequency, pain control was achieved. Routine dental procedures, restorations, root planing and curettage were accomplished painlessly in a significant percentage of patients who used TENS. The dental application of TENS was renamed electronic dental anesthesia (EDA).[14-16] When EDA worked, it worked well. Unfortunately, it turned out that EDA did not produce a consistently reliable level of pain control. Additionally, the intraoral electrodes were cumbersome and did not adhere well to the saliva-soaked mucous membranes in the mouth. This led to patients experiencing the momentary sensation of an electric shock. Though TENS remains an extremely valuable technique in physical therapy and sports medicine, interest in and use of EDA has decreased in dentistry.

Figure 1. Transcutaneous electrical nerve stimulation

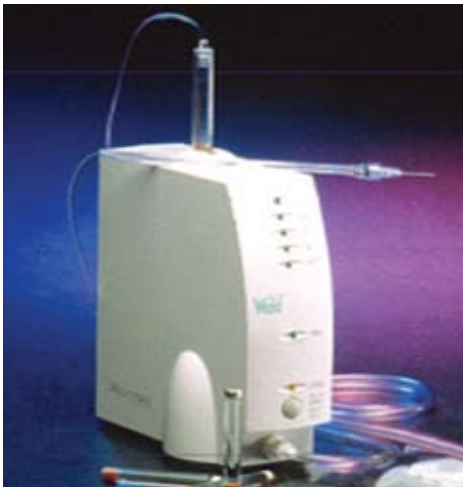
Vibraject

The Vibraject utilizes vibration to reduce the sensation of pain during injections. This device utilizes a battery-powered attachment that is placed over a regular dental syringe and provides a series of fine vibrations to the needle tip during introduction of the local anesthetic. The Vibraject has been found to reduce pain during local anesthesia procedures and is not restricted to one injection technique.

Computer-Controlled Local Anesthetic Delivery Systems (the 1990s–present)

In the mid-1990s, work began on the development of local anesthetic delivery systems that incorporated computer technology to control the rate of flow of the anesthetic solution through the needle. This concept is now called computer-controlled local anesthetic delivery (CCLAD).[17] The first of these CCLAD devices, the Wand™ (Milestone Scientific, Inc., Livingston, N.J.), was introduced in 1997. The system enabled a dentist or hygienist to accurately manipulate needle placement with fingertip accuracy and deliver the LA with a foot-activated control. The lightweight handpiece is held in a pen-like grasp that provides the user with greater tactile sensation and control compared to a traditional syringe. The available flow rates of LA delivery are controlled by a computer and thus remain consistent from one injection to the next.

Figure 2. The Wand and handpiece



The Wand represents a significant change in the manner in which an LA injection is administered. The operator needs only to focus his or her attention on insertion and positioning of the needle, allowing the motor in the CCLAD device to administer the drug at a preprogrammed rate of flow. The greater control over the syringe and the fixed flow rates of the LA drug are responsible for a significantly improved injection experience, as demonstrated in many clinical studies conducted with CCLAD devices in dentistry.[18-21] A growing number of clinical trials in medicine also demonstrate measurable benefits of CCLAD technology.[22,23]

Dr. Mark Hochman and coworkers were the first to demonstrate a marked reduction in pain perception for injections using a CCLAD system.[24] Fifty blindfolded dentists participated in a controlled clinical study (they received the injection) comparing the standard manual syringe to a CCLAD system (the Wand) for palatal injections. Forty-eight (96%) preferred the CCLAD injections. Overall, pain perception was reduced two- to threefold when compared to the standard manual syringe. Nicholson et al. conducted a randomized clinical study in which two operators administered four different types of dental injections, comparing CCLAD to a standard syringe.[19] Mean injection discomfort ratings were found to be consistently lower with CCLAD when compared to the manual syringe. Two-thirds of the patients wanted future dental injections to be performed with a CCLAD system. The investigators in the study increasingly preferred to perform all injections with the CCLAD technology. Fukayama et al. conducted a controlled clinical study evaluating pain perception of a CCLAD device. Seventeen of the 20 subjects reported a slight or no-pain rating on a visual analogue scale (VAS) for palatal injections administered with CCLAD. Fukuyama et al. concluded that "the new system provides comfortable anesthesia for patients and can be a good alternative for conventional manual syringe injection."[20]

Figure 3. Comfort Control Syringe

Figure 4. Anaeject

Several CCLAD systems are available, including the Wand/CompuDent™ system, Comfort Control Syringe™, QuickSleeper™ and Anaeject™. Both the Comfort Control Syringe and the Anaeject regulate the speed of injection, starting slowly and accelerating the speed of injection to minimize pain. The Comfort Control Syringe has five pre-programmed speeds for different injection techniques and can be used for all injection techniques. The Anaeject has three pre-programmed speeds. CCLAD allows LAs to be administered comfortably to the patient in virtually all areas of the oral cavity. This is of greatest importance in the palate, where the level of patient discomfort can be quite significant. Computerized delivery of local anesthesia for palatal infiltrations has been found to result in low levels of stress and a low pain reaction, with the stress and pain reaction equivalent to that experienced following buccal infiltrations without computerized delivery.[25] The nasopalatine nerve block may be administered atraumatically in most patients.[21,24]

New Injection Techniques

Two new injection techniques, the AMSA[26,27] and P-ASA,[28-32] have been described since the development of CCLAD. Though either may be administered with a traditional local anesthetic syringe, the level of patient discomfort minimizes their administration in this manner. CCLAD has made both techniques quite popular among doctors and dental hygienists, as the level of patient discomfort is minimal.

AMSA

The anterior middle superior alveolar nerve block provides pulpal anesthesia to the maxillary incisors, canines and premolars on the side of injection.[26,27] Soft tissue anesthesia is achieved for the entire hard palate on both that side and the intraoral mucosa of the five anesthetized teeth. Significantly, no extraoral anesthesia develops with the AMSA, a benefit to both the patient (functionally and esthetically) and the doctor during cosmetic procedures (no drooping of the upper lip).[27] Perry and Loomer presented data from a single-blind crossover study comparing CCLAD to traditional syringe delivery of LA for quadrant scaling and root planing. Twenty

subjects received the anterior middle superior alveolar nerve block (AMSA) injection. Scores for the AMSA injection revealed a highly significant difference in favor of the computer-controlled device ($p<0.0001$).[21]

Figure 5. Anesthesia provided by AMSA

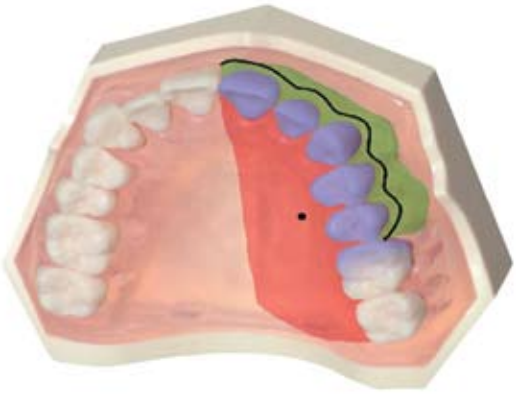


Figure 6. AMSA nerve block

P-ASA

The palatal approach-anterior superior alveolar nerve block provides pulpal anesthesia to the six anterior teeth – canine to canine bilaterally as well as the palatal and labial gingiva and mucoperiosteum and bone overlying these teeth. As noted with the AMSA, there is no collateral anesthesia extraorally.[33]

Figure 7. Anesthesia provided by P-ASA

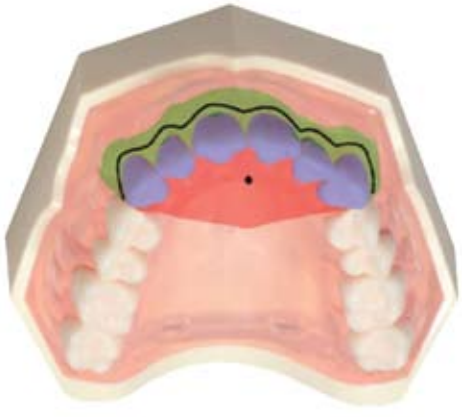
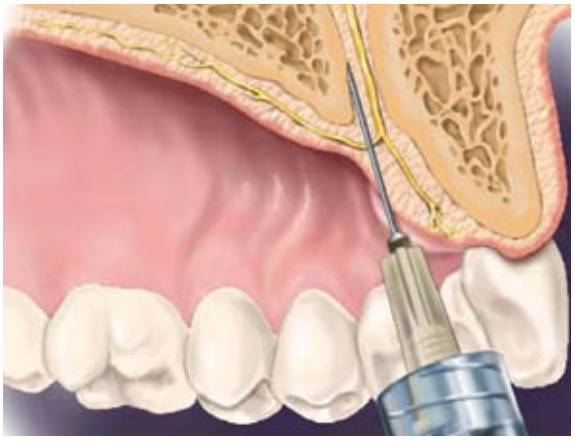


Figure 8. P-ASA nerve block



Periodontal ligament injection (PDL)

Another injection technique – the periodontal ligament injection (PDL), also known as the intraligamentary injection (ILI) – has been extremely useful when anesthesia of a single tooth in the mandible is required.[34] Traditionally, the inferior alveolar nerve block (IANB) is administered, providing, when it is successful, anesthesia to all eight teeth in the quadrant as well as to the soft tissue of the tongue, lower lip and chin. Many patients complain about the degree and length of residual soft tissue anesthesia related to the IANB, which, when an epinephrine-containing LA is used, can persist for up to 5 hours after treatment is concluded.[35]

The PDL injection provides pulpal anesthesia to the tooth, with only localized soft tissue anesthesia developing. When administered in the mandible, there is no associated extraoral or lingual anesthesia.

Though PDL is a technique with a relatively high success rate, many doctors occasionally find it frustrating to deliver, as it may be difficult to locate the precise site for needle placement (within or at the entrance to the PDL). The bitter-tasting LA solution may also leak out of the injection site into the patient's mouth. When the traditional syringe is used, the application of high pressure is needed to deliver the LA into the dense oral tissues at the PDL injection site. This has resulted in many patients complaining that the PDL injection was painful.[36-38] The high pressures can also cause tissue damage, as evidenced by histologic, animal and human studies.[39-41] Recommendations for the PDL injection were a volume of solution of 0.2 to 0.4 mL per root.[34]

However, a study in children found that use of a Wand for computer controlled delivery of local anesthesia to the upper incisors using the PDL technique resulted in the same efficacy as with conventional buccal infiltration. The patients appeared comfortable when CCLAD was used but demonstrated discomfort with the conventional technique.[42]

Figure 9. PDL injection site

Intraosseous anesthesia

Intraosseous anesthesia involves the placement of local anesthetic directly into the cancellous bone spaces adjacent to the tooth or teeth that require anesthesia. This technique offers rapid onset of pulpal anesthesia. Methods used have included the use of two-step and one-step techniques. Using a two-step technique, a bur is first used to penetrate the bone using a slow-speed handpiece, after which the local anesthetic is placed. A one-step technique (IntraFlow™ Anesthesia Delivery System) uses a slow-speed handpiece with a needle (perforator) and transfuser, resulting in penetration of the bone and immediate flow of anesthetic without a separate step. This technique uses a foot pedal to regulate flow. One recent study found IntraFlow to provide reliable anesthesia of posterior mandibular teeth in 13 of 15 subjects, compared to 9 of 15 with an inferior alveolar nerve block.[43]

Figure 10. IntraFlow

Single-Tooth Anesthesia

In 2006, the manufacturers of the original CCLAD, the Wand, introduced a new device, Single Tooth Anesthesia (STA™). STA incorporates dynamic pressure-sensing (DPS) technology that provides a constant monitoring of the exit pressure of the local anesthetic solution in real time during all phases of the drug's administration.[44] Originally designed for use in medicine in epidural regional anesthesia,[45,46] STA utilizes an adaptation of DPS to dentistry as a means of overcoming the problems associated with PDL injection,[47] and simplifies AMSA and P-ASA injections. The system can be utilized for all traditional intraoral injection techniques. Unlike earlier variants, the STA includes a training mode that verbally explains how to use the device, and multi-cartidge and auto-cartridge retraction features.

Figure 11. STA

Using the STA for PDL injection, the needle tip is guided to the correct anatomic position by DPS technology sensing the pressure outside the needle tip. With a PDL injection, the needle tip passes near and/or through tissues of varying density, including bone and attached and unattached gingiva.[48] The DPS system provides confirmation (in audible tones, visual displays and spoken alerts) that the needle tip is in the desired location and has not moved outside this area during drug administration. DPS alerts the user if leakage of LA occurs (a common problem when traditional syringes are used for the PDL), which results from improper needle placement, insufficient hand pressure on the syringe, or internal leaking from the cartridge or syringe.

Since the pressure of the LA is strictly regulated by the STA system, a greater volume of LA can be administered with increased comfort and less tissue damage than seen with traditional syringes or PDL pressure devices.[49] Recommended LA volumes for the PDL when the STA is used with lidocaine are 0.9 mL for single-rooted teeth and 1.8 mL for multi-rooted

teeth. If articaine is used, the dosages for single-rooted and multi-rooted teeth are 0.45 mL and 0.9 mL respectively.

Summary

Local anesthesia forms the backbone of pain control techniques in dentistry, and local anesthetics are the safest and most effective drugs in all of medicine for the prevention and management of pain. Nonetheless, the administration of these drugs is the most frightening and uncomfortable part of the dental appointment for most patients. The needle is the most fear-inducing part of the armamentarium for the delivery of LAs. Over the years, many futile attempts have been made to provide clinically adequate pain control without the need for injection of drugs. Absent this ability, recent developments in CCLAD systems have made the delivery of local anesthesia to patients significantly more comfortable and, with the PDL, AMSA and P-ASA injections, considerably more successful. The ability to deliver painless injections and a desirable level and duration of anesthesia results in reduced patient fear, reduced patient stress (and therefore reduced stress for the clinician) and can aid patient compliance with current and future dental treatment.

References

1. Brennan PA, Mackenzie N, Oeppen RS, Kulamarva G, Thomas GJ, Spedding AV. Prospective randomized clinical trial of the effect of needle size on pain, sample adequacy and accuracy in head and neck fine-needle aspiration cytology. Head Neck. 2007;29(10):919-22.
2. Daltrey IR, Kissin MW. Randomized clinical trial of the effect of needle gauge and local anaesthetic on the pain of breast fine-needle aspiration cytology. Br J Surg. 2000;87(6):777-9.
3. Jeske AH, Blanton PL. Misconceptions involving dental local anesthesia. Part 2. Pharmacology. Tex Dent J. 2002;119:310-4.
4. Hamburg HL. Preliminary study of patient reaction to needle gauge. NY State Dent J. 1972;38:425-6.
5. Flanagan T, Wahl MJ, Schmitt MM, Wahl JA. Size doesn't matter: needle gauge and injection pain. Gen Dent. 2007;55(3):216-7.
6. De St. Georges J. How dentists are judged by patients. Dent Today. 2004;23(8):96-9.
7. Malamed SF. Basic Injection Technique, in Malamed SF. *Handbook of Local Anesthesia*. 6th edition, CV Mosby, St. Louis 2004.
8. Friskopp J, Nilsson M, Isacsson G. The anesthetic onset and duration of a new lidocaine/prilocaine gel intrapocket anesthetic (Oraqix) for periodontal scaling/root planing. J Clin Periodontol. 2001;28(5):453-8.
9. Donaldson D, Gelskey SC, Landry RG, Matthews DC, Sandhu HS. A placebo-controlled multi-centred evaluation of an anaesthetic gel (Oraqix) for periodontal therapy. J Clin Periodontol. 2003;30(3):171-5.
10. Al-Melh MA, Andersson L. Comparison of topical anesthetics (EMLA/Oraqix vs. benzocaine) on pain experienced during palatal needle injection. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(5):e16-20.
11. Al-Melh MA, Andersson L. Reducing pain from palatal needle stick by topical anesthetics: a comparative study between two lidocaine/prilocaine substances. J Clin Dent. 2008;19(2):43-7.
12. Smith MJ, Hutchins RC, Hehenberger D. Transcutaneous neural stimulation use in postoperative knee rehabilitation. Am J Sport Med. 1983;11:75-82.
13. Khadilkar A, Odebiyi DO, Brosseau L, Wells GA. Transcutaneous electrical nerve stimulation (TENS) versus placebo for chronic low-back pain. Cochrane Database Syst Rev. 2008;(4):CD003008.
14. Meechan JG, Gowans AL, Wellbury RR. The use of a patient-controlled transcutaneous electrical nerve stimulation (TENS) to decrease the discomfort of regional anaesthesia in dentistry. A randomized controlled clinical trial. J Dent. 1998;26(5):417-20.
15. Hochman R. Neurotransmitter modulator (TENS) for control of dental operative pain. J Am Dent Assoc. 1988;116:208-12.
16. Malamed SF, Quinn CL, Torgersen RT, Thompson W. Electronic dental anesthesia for restorative dentistry. Anesth Prog. 1989;36:195-7.
17. Proceedings of the 1st Annual Computer-Controlled Local Anesthesia Delivery (C-CLAD) System meeting. Introductory remarks. New Orleans, La., Feb 2008.
18. Gibson RS, Allen K, Hutfless S, Beiraghi S. The Wand vs. traditional injection: a comparison of pain related behaviors. Pediatr Dent. 2000;22:458-62.
19. Nicholson JW, Berry TG, et al. Pain perception and utility: a comparison of the syringe and computerized local injection techniques. Gen Dent. 2001;167-72.
20. Fukayama H, Yoshikawa F, Kohase H, Umino M, Suzuki N. Efficacy of anterior and middle superior alveolar (AMSA) anesthesia using a new injection system: the Wand. Quintess Int. 2003;34(7):537-41.
21. Perry DA, Loomer PM. Maximizing Pain Control. The AMSA Injection can provide anesthesia with few injections and less pain. Dimensions of Dental Hygiene. 2003;1:28-33.
22. Tan PY, Vukasin P, Chin ID, Ciona CJ, et al.The Wand local anesthetic delivery system. Dis Colon Rectum. 2001;44:686-9.
23. Landsman A, DeFronzo D, Hedman J, McDonald J. A new system for decreasing the level of injection pain associated with local anesthesia of a toe. Am Acad Podiat Med. 2001; Abstract.
24. Hochman MN, Chiarello D, Hochman CB, Lopatkin R, Pergola S. Computerized Local Anesthesia Delivery vs. Traditional Syringe Technique. NY State Dent J. 1997;63:24-9.

25. Ashkenazi M, Blumer S, Eli I. Effectiveness of various modes of computerized delivery of local anesthesia in primary maxillary molars. Pediatr Dent. 2006;28(1):29-38.
26. Friedman MJ, Hochman MN. The AMSA injection: a new concept for local anesthesia of maxillary teeth using a computer-controlled injection system. Quintess Int. 1998;29(5):297-303.
27. Malamed SF. Techniques of Maxillary Anesthesia, in Malamed SF. *Handbook of Local Anesthesia*. 6th edition, CV Mosby, St. Louis 2004, p. 213-217.
28. Malamed SF. Techniques of Maxillary Anesthesia, in Malamed SF. *Handbook of Local Anesthesia*. 6th edition, CV Mosby, St. Louis 2004, p. 217-220.
29. Friedman MJ, Hochman MN. P-ASA block injection: a new palatal technique to anesthetize maxillary anterior teeth. J Esthet Dent. 1999;11(2):63-71.
30. Friedman MJ, Hochman MN. Using AMSA and P-ASA nerve blocks for esthetic restorative dentistry. Gen Dent. 2001;49(5):506-11.
31. Ram D, Kassirer J. Assessment of a palatal approach-anterior superior alveolar (P-ASA) nerve block with the Wand in paediatric dental patients. Int J Paediatr Dent. 2006;16(5):348-51.
32. Friedman MJ, Hochman MN. P-ASA block injection: a new palatal technique to anesthetize maxillary anterior teeth. J Esthet Dent. 1999;11(2):63-71.
33. Friedman MJ, Hochman MN. Using AMSA and P-ASA nerve blocks for esthetic restorative dentistry. Gen Dent. 2001;49(5):506-11.
34. Malamed SF. The periodontal ligament (PDL) injection: an alternative to inferior alveolar nerve block. Oral Surg. 1982;53:117-21.
35. Rafique S, Fiske J, Banerjee A. Clinical trial of an air-abrasion/chemomechanical operative procedure for restorative treatment of dental patients. Caries Res. 2003;37:360-4.
36. White JJ, Reader AL, Beck M, et al. The periodontal ligament injection: a comparison of the efficacy in human maxillary and mandibular teeth. J Endod. 1988;14:508-14.
37. Faulkner RK. The high-pressure periodontal ligament injection. Br Dent J. 1983;154:103-5.
38. Miller AG. A clinical evaluation of the Ligmaject periodontal ligament injection syringe. Dent Update. 1983;10:639-43.
39. Pashley EL, Nelson R, Pashley DH. Pressures created by dental injections. J Dent Res. 1981;60:1742-8.
40. Pertot WJ, Dejou J. Bone and root resorption. Effects of the force developed during periodontal ligament injections in dogs. Oral Surg Oral Med Oral Path. 1992;74:357-65.
41. Brannstrom M, Nordenvall KJ, Hedstrom KG. Periodontal tissue changes after intraligamentary anesthesia. ASCD J Dent Child. 1984;49:417-23.
42. Ran D, Peretz B. Assessing the pain reaction of children receiving periodontal ligament anesthesia using a computerized device (Wand). J Clin Pediatr Dent. 2003;27(3):247-50.
43. Remmers T, Glickman G, Spears R, He J. The efficacy of IntraFlow intraosseous injection as a primary anesthesia technique. J Endod. 2008;34(3):280-3.
44. Hochman M. Inventor: Pressure/force computer controlled drug delivery system and the like. Assigned: Milestone Scientific, Inc. US Patent 6,200,289. March 2001.
45. Ghelber O, Gebhard R, Adebayo G, et al. Utilization of the CompuFlo in determining the pressure of the epidural space: a pilot study. Anesth Analg. 2005;S100-89.
46. Ghelber O, Gebhard R, Szmuk P, et al. Identification of the epidural space – a pilot study of a new technique. Anesth Analg. 2005;S100-255.
47. Hochman MN. Single-tooth anesthesia: Pressure-sensing technology provides innovative advancement in the field of dental local anesthesia. Compendium. 2007;28(4):186-93.
48. Hochman MN, Friedman MJ, Williams W, Hochman CB. Interstitial tissue pressure associated with dental injections: A clinical study. Quintess Int. 2006;37(6):469-76.
49. Ferrari M, Cagidiaco MC, Vichi A, Goracci C. Efficacy of the Computer-Controlled Injection System STA™, and the dental syringe for intraligamentary anesthesia in restorative patients. Inter Dent SA. 2008;11(1):4-12.

Author Profile

Dr. Malamed graduated from New York University College of Dentistry in 1969, and completed his residency in anesthesiology at Montefiore Hospital and Medical Center. In 1973, Dr. Malamed joined the faculty of the University of Southern California School of Dentistry in Los Angeles, where he is currently professor of Anesthesia and Medicine. Dr. Malamed is a diplomate of the American Dental Board of Anesthesiology, and has authored more than 135 scientific papers and 17 chapters in medical and dental journals and textbooks. Dr. Malamed is the author of three widely used textbooks, published by CV Mosby Inc: *Handbook of Local Anesthesia* (5th ed., 2004); *Handbook of Medical Emergencies in the Dental Office* (6th ed. 2007); and *Sedation: A Guide to Patient Management* (5th ed. 2009) as well as two interactive DVDs: *Emergency Medicine* (2nd ed. 2008) and *Malamed's Local Anesthetic Technique* (2004).

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Questions

1. Dr. Horace Wells, a Connecticut dentist, has received recognition as the founder of anesthesia.
   a. True
   b. False

2. The Halstead approach is used for the _____.
   a. superior alveolar nerve block
   b. inferior alveolar nerve block
   c. infiltration technique
   d. all of the above

3. _____ is a requirement for a local anesthetic agent.
   a. Efficacy
   b. Safety
   c. Biocompatibility
   d. all of the above

4. By the 1940s, dissatisfaction with procaine was becoming common and was due to _____.
   a. the long onset time for anesthesia
   b. the limited duration time for modern dental procedures
   c. true, documented and reproducible allergies
   d. all of the above

5. Lidocaine has a faster onset, greater reliability and, when combined with epinephrine, a shorter duration of action than procaine.
   a. True
   b. False

6. The local anesthesia (LA) drugs presently available represent the safest and the most effective drugs in all of medicine for the prevention and management of pain.
   a. True
   b. False

7. Dental needles are usually 25-, 27- or 30-gauge, produce considerably less pain than those gauges used in medicine, and needle-stick pain can be distinguished by which of these gauges was used.
   a. True
   b. False

8. The ability of a dentist to _____ is considered by patients to be the most important factor when it comes to selecting a dentist.
   a. provide long-lasting restorations
   b. extract teeth
   c. administer a local anesthetic injection painlessly
   d. all of the above

9. Application of a small amount of _____ to the injection site prior to needle penetration is an integral step in the delivery of atraumatic injections.
   a. local anesthetic
   b. topical anesthetic
   c. heat
   d. all of the above

10. The only topically applied local anesthetic that is markedly better than the others is _____, simply because, along with it being an effective topical anesthetic, it is unique in that it possesses vasoconstricting actions.
    a. articaine
    b. cocaine
    c. lidocaine
    d. bupivacaine

11. Transcutaneous electrical nerve stimulation provides a consistently reliable level of anesthesia.
    a. True
    b. False

12. Utilizing vibration can reduce the sensation of pain during injections.
    a. True
    b. False

13. The development of local anesthetic delivery systems that incorporated computer technology to control the rate of flow of the anesthetic solution through the needle first began in the _____.
    a. late 1970s
    b. mid-1980s
    c. mid-1990s
    d. none of the above

14. The first computer-controlled local anesthetic delivery device was introduced in 1997.
    a. True
    b. False

15. Using CCLAD, the available flow rates of LA delivery are controlled by a computer and thus remain consistent from one injection to the next.
    a. True
    b. False

16. The first to demonstrate a marked reduction in pain perception for injections using a CCLAD system were _____.
    a. GV Black and coworkers
    b. Dr. Fred Bloch and coworkers
    c. Dr. Mark Hochman and coworkers
    d. none of the above

17. In a controlled clinical study involving 50 blindfolded dentists, comparing the standard manual syringe to a CCLAD system (the Wand) for palatal injections, _____ preferred the CCLAD injections.
    a. 66%
    b. 76%
    c. 86%
    d. 96%

18. Nicholson et al. conducted a randomized clinical study in which two operators administered four different types of dental injections; they compared CCLAD to a standard syringe and found that, as a result, two-thirds of the patients wanted future dental injections to be performed with a CCLAD system.
    a. True
    b. False

19. Several CCLAD systems are available that are preprogrammed to regulate the rate of flow of local anesthetic.
    a. True
    b. False

20. Computerized delivery of local anesthesia for palatal infiltrations has been found to result in _____.
    a. low levels of stress
    b. decreased duration of anesthesia
    c. a low pain reaction
    d. a and c

21. Since the development of CCLAD, _____ injection techniques have been described.
    a. the HAMSA
    b. the AMSA and P-ASA
    c. PDL
    d. all of the above

22. The anterior middle superior alveolar nerve block provides pulpal anesthesia to the _____.
    a. maxillary incisors and canines on the side of injection
    b. maxillary incisors, canines and premolars on the side of injection
    c. maxillary incisors, canines and premolars bilaterally
    d. all of the above

23. No extraoral anesthesia develops with the anterior middle superior alveolar nerve block.
    a. True
    b. False

24. The palatal approach-anterior superior alveolar nerve block provides pulpal anesthesia to the anterior teeth bilaterally.
    a. True
    b. False

25. With the palatal approach-anterior superior alveolar nerve block, there is collateral extraoral anesthesia.
    a. True
    b. False

26. With a mandibular PDL injection _____.
    a. pulpal anesthesia to the tooth is obtained
    b. localized soft tissue anesthesia develops
    c. there is no associated extraoral or lingual anesthesia
    d. all of the above

27. Single Tooth Anesthesia utilizes an adaptation of DPS to dentistry as a means of overcoming the problems associated with the PDL injection and simplifies AMSA and P-ASA injections.
    a. True
    b. False

28. A greater volume of LA can be administered with increased comfort and less tissue damage than seen with traditional syringes or PDL pressure devices if the pressure of the LA is strictly regulated by the CCLAD system.
    a. True
    b. False

29. Recommended LA volumes for the PDL when the Single Tooth Anesthesia CCLAD system is used are the same whether lidocaine or articaine is used.
    a. True
    b. False

30. The ability to deliver painless injections and a desirable level and duration of anesthesia _____.
    a. results in reduced patient fear
    b. results in reduced stress for the patient and clinician
    c. can aid patient compliance with treatment
    d. all of the above

ANSWER SHEET

Anesthetic Agents and Computer-Controlled Local Anesthetic Delivery (CCLAD)

Name: Title: Specialty:

Address: E-mail:

City: State: ZIP: Country:

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Requirements for successful completion of the course and to obtain dental continuing education credits: 1) Read the entire course. 2) Complete all information above. 3) Complete answer sheets in either pen or pencil. 4) Mark only one answer for each question. 5) A score of 70% on this test will earn you 4 CE credits. 6) Complete the Course Evaluation below. 7) Make check payable to PennWell Corp.

Educational Objectives

1. Know the types of local anesthetics that have been introduced to dentistry, as well as the disadvantages of the earliest local anesthetic agents
2. Understand the disadvantages associated with local anesthetics from the patient's perspective, as well as the topical anesthetic agents available and their uses
3. Know and discuss the use of computer-controlled local anesthetics delivery (CCLAD) systems
4. Know the types of injections that have recently been introduced and the adjunctive role of CCLAD for these techniques

Course Evaluation

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met? Objective #1: Yes No Objective #3: Yes No
   Objective #2: Yes No Objective #4: Yes No
2. To what extent were the course objectives accomplished overall? 5 4 3 2 1 0
3. Please rate your personal mastery of the course objectives. 5 4 3 2 1 0
4. How would you rate the objectives and educational methods? 5 4 3 2 1 0
5. How do you rate the author's grasp of the topic? 5 4 3 2 1 0
6. Please rate the instructor's effectiveness. 5 4 3 2 1 0
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8. Do you feel that the references were adequate? Yes No
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10. If any of the continuing education questions were unclear or ambiguous, please list them.

    _____

11. Was there any subject matter you found confusing? Please describe.

    _____

    _____

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    _____

    _____

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4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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CLAD