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Review Article

RECENT ADVANCES IN LOCAL ANESTHESIA – A REVIEW

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ABSTRACT

Local anesthetic solutions have been utilized in clinical dentistry to alleviate or eliminate pain associated with invasive procedures as early as the 19th century. An important requirement prior to initiating endodontic or operative dental treatment is the ability to achieve and maintain profound anesthesia. Local anesthetics are correctly considered to be the most important drugs used in clinical dentistry.

INTRODUCTION

Progress in the treatment of dental disease had to await the development of methods of pain control.[1] Pain control is the foundation of successful dental patient management. A relaxed, confident patient will respond better to local anesthesia. An anxious or phobic dental patient may require some type of intervention strategy to relieve the stress before administering anesthesia. [2] Local anesthesia has been defined as a loss of sensation in an area of the body caused by a depression of excitation in nerve endings or an inhibition of the conduction process in peripheral nerves (Covino and Vassallo 1976).[3]

Classification of Local Anesthetics[3]

Esters

Esters of Benzoic acid	**Amides**
Butacaine	Articaine
Cocaine	Bupivacaine
Benzocaine	Dibucaine
Hexylcaine	Etidocaine
Piperocaine	Lidocaine
Tetracaine	Mepicvacaine
	Prilocaine
	Ropivacaine

Esters of para amino benzoic acid	**Quinolone**
Chloroprocaine	Centbucridine
Procaine	
Propoxycaine	

Constituents of Local Anesthetics[3]

Local anesthetic agent

It interrupts the propagated nerve impulse, preventing it from reaching the brain.

Vasoconstrictor

It is to increase the safety and duration and depth of action of local anesthetic

Reducing Agents (Antioxidant)

To prevent the oxidation of the vasopressor by oxygen which might be trapped in the cartridge during manufacture or diffuse through the semipermeable diaphragm after filling.

Preservatives

Bacteriostatic agent.

Vehicle

The anesthetic agent and its additives are dissolved in sodium chloride. This isotonic vehicle minimizes discomfort during injection.

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Distilled Water

Distilled water is added as the diluent to provide the volume of the solution in the cartridge.

Selection of Local Anesthetic Agent [4]

According to AAPD guidelines, selection of local anesthetic solution is based upon

1. The patient's medical history and mental developmental status.
2. The anticipated duration of the procedure.
3. The need for hemorrhage control.
4. The planned administration of other agents (sedative agents and general anesthesia)
5. The practitioner's knowledge of the anesthetic agent

Local anesthetics in children [5]

Fixed pediatric dosage recommendations for a given age range are no longer endorsed for local anesthetic agents. Available data suggest that adverse reactions in the pediatric population are commonly caused by inadequate dose reduction. Maximum recommended doses of local anesthetics are based upon the weight of the child, usually expressed as milligrams per kilogram of body weight. For very obese children, the maximum dose should be calculated on the basis of lean body weight, not the true body weight. The specific number of milligrams per kilogram used for calculating the maximum recommended dose differs among the various local anesthetics.

Example calculations of maximum local anesthetic doses for a 15-kg (33-lb) child. [6]

Articaine

5 mg/kg maximum dose × 15 kg = 75 mg
4% articaine = 40 mg/mL
75 mg/(40 mg/mL) = 1.88 mL
1 cartridge = 1.8 mL
Therefore, 1 cartridge is the maximum.

Lidocaine

7 mg/kg × 15 kg = 105 mg
2% lidocaine = 20 mg/mL
105 mg/(20 mg/mL) = 5.25 mL
1 cartridge = 1.8 mL
Therefore, 2.9 cartridges is the maximum.

Mepivacaine

6.6 mg/kg × 15 kg = 99 mg
3% mepivacaine = 30 mg/mL
99 mg/(30 mg/mL) = 3.3 mL
1 cartridge = 1.8 mL
Therefore, 1.8 cartridges is the maximum.

Prilocaine

8 mg/kg × 15 kg = 120 mg;
4% prilocaine = 40 mg/mL
120 mg/(40 mg/mL) = 3 mL
1 cartridge = 1.8 mL
Therefore, 1.67 cartridges is the maximum.

Topical Anesthetics [3]

Topical anesthesia is an important component for atraumatic administration of local anesthesia.

They reduce the discomfort that may be associated with the insertion of the needle before the injection of local anesthetic.[7] Topical anesthetics are available in gel, liquid, ointment and pressurized spray forms. The higher concentration facilitates diffusion of the drug through the mucous membrane but also increases the risk of toxicity, both locally to the tissues and systemically. Topical anesthetics do not contain vasoconstrictors hence vascular absorption is rapid, and blood levels may quickly reach those achieved by direct IV administration. Many topical anesthetics used effectively via injection prove to be ineffective when applied topically because the concentrations necessary to produce anesthesia via topical application are high, with significantly increased overdose and local tissue toxicity potential.

A topical anesthetic is effective only on surface tissues (2 to 3 mm). The base forms of benzocaine and lidocaine are slowly absorbed into the cardiovascular system and hence less likely to produce an overdose reaction.

Dentipatch a small adhesive patch promises relief from dental pain up to 45 minutes contains lignocaine.[8,9]. It has reduced pain compared to benzocaine gel and was preferred by most children. [10]

Recent Advances

Transcutaneous Electrical Nerve Stimulation (Tens) [11]

It is an electroanalgesia and used in simple restorations and periodontal procedures. Two mechanisms have been explained. One is that TENS stimulate the release of the body's endogenous opiates. The other is based on Melzack and Wall's gate control theory.

Computer - Controlled Local Anesthetic Delivery System [3,12]

The standard dental syringe is a simple mechanical instrument introduced by Charles Pravaz in 1853. The dental Syringe is a drug delivery device requiring the operator simultaneously attempt to control the variables of drug infusion and the movement of the penetrating needle. The operator's inability to precisely control both of these activities during an injection can compromise an injection technique. In addition, a traditional syringe is handled with a palm-thumb grasp, which is not designed for ideal ergonomics or needle control during the injection. For certain practitioners, those with small hands, just holding a syringe with a full cartridge of anesthetic may be difficult.

In 1997 the first computer-controlled local anesthetic delivery system (CCLAD) was introduced into dentistry. The WAND[13,14] manufactured by Milestone Scientific, Inc, Livingston, NJ, was designed to improve on the ergonomics and precision of the dental syringe. The core technology is an automatic delivery system of local anesthetic injection at a fixed pressure; volume ratio regardless of variations in tissue resistance. This results in a controlled, highly effective and comfortable injection even in resilient tissues such as the palate and the periodontal ligament. The system enables a dentist to accurately manipulate needle placement with a foot-activated

control. The lightweight handpiece is held in a pen-like grasp that provides increased tactile sensation and control compared with a traditional syringe. The available flow rates of local anesthetic delivery are computer controlled and thus remain consistent from one injection to the next. The CCLAD system represents a significant change in the manner in which local anesthetic injection is administered. The operator focuses attention on needle insertion and positioning, allowing the motor in the device to administer the drug at a preprogrammed rate of flow. It is likely that the greater ergonomic control coupled with the fixed flow rates are responsible for an improved injection experience in many clinical studies conducted with this device in dentistry. Currently, available CCLAD are, The WAND/CompuDent system, Comfort Control Syringe, Quick sleeper.

Wand when used with the palatal approach to P-ASA and AMSA offers less pain and behaviour disruption and possibly increased safety, making it a potential asset to any practioner's armamentarium.[15]

A.M.Palm states that mandibular alveolar nerve block analgesia seems to be less painful when using the wand than when using a traditional syringe. [16]

Comfort Control System

Both CCS and traditional anesthesia were rated similarly on level of anxiety, the profoundness of anesthesia, overall experience and comfort with the injection.[17]

Electronic Dental Anesthesia[18,19]

Contraindications to the use of EDA are the same as those for TENS. These include patients with prior history of cerebrovascular accident (CVA) or other neurological disorders (epilepsy), pregnant women, and patients with cardiac pacemakers. The lower (and upper) age limits for successful use of EDA depend on upon the ability of the patient to understand the concept involved: that the doctor are responsible for their comfort during treatment. The mature younger patient can successfully receive EDA. To date our youngest patient has been 11 years of age (restorative treatment). Temporomandibular joint pain has been treated by dentists and physical therapists with TENS with great success for many years.

EDA was less effective than LA in controlling pain during cavity preparation in children aged 6 to 12[20]

The Wand/Compudent

Advantages

1. Precise control of flow rate and pressure produces a more comfortable injection even in tissues with low elasticity
2. Increased tactile "feel" and ergonomics from the lightweight Wand handpiece
3. Non-Threatening
4. Automatic aspiration
5. Rotational insertion technique minimizes needle deflection

Disadvantages

1. Requires additional armamentarium
2. Cost

The Wand/Compu Dent System[21] utilizes a single-use disposable "safety" handpiece. A conventional medical Luer-Lok needle is attached to the handle. Luer-Lok needles are available in lengths and gauges similar to conventional needles, the handle attaches to a cartridge holder through a 60-inch microtube, the inner diameter of which is 0.013inch and can hold a volume of less than 0.2ml of fluid. The cartridge holder accepts any standard 1.8ml dental anesthetic cartridge. The Wand handpiece provides increased tactile control and ergonomics. In two clinical trials operator were able to achieve a more comfortable needle puncture for patients when using the Wand hand piece compared with a traditional syringe. This was attributed to the lightweight economically designed hand piece allowing for enhanced tactile sensation. The Wand handpiece is also less threatening to the patient compared with other injection devices. Kudo and associates compared ten different injection delivery system. The Wand/ CompuDent system was rated the least anxiety-producing injection instruments based on the visual appearance. This may also explain why Gibson and associates found disruptive behavior in pediatric patients to be significantly reduced when using this same equipment. The pen-like grasp has an additional advantage of allowing the operator to rotate the handpiece during penetration and insertion. Hochman and Friedman demonstrated the rotation of the hand piece and needle minimizes both needle deflection and the force necessary for tissue penetration during needle insertion, greater accuracy can be obtained for injection such as the inferior alveolar nerve block injection where deeper tissue penetration is necessary. The Wand/ CompuDent system administers local anesthetic at two specific rates of delivery.

The slow rate is 0.5ml/min and the fast rate is 1.8ml/min. An aspiration test can be activated at any time by simply releasing the pressure on the foot-rheostat starting a 4.5-second aspiration cycle.[3]

The Wand/ CompuDent system delivers a controlled rate of flow and controls the pressure developing within the tissues as the local anesthetic is introduced. When injecting into deeper tissues such as on the palate and in the PDL space using a standard manual syringe, the operator encounters significant resistance. More pressure must be applied to the plunger to overcome this resistance or the local anesthetic to be deposited into the tissue. This results in the production of extremely high pressures within non-resilient tissues, leading to pain or tissue damage. The traditional syringe possesses a mechanical design that does not allow pressure to flow rate to be precisely controlled. Pressures generated with a traditional syringe have been shown to be as high as 600 psi or even more. Histological studies of the PDL injection performed with traditional syringe demonstrated severe tissue damage from the high pressures produced with these delivery instruments. The Wand/ CompuDent system permits both a precise rate of flow and a controlled pressure to be maintained irrespective of the type of tissue into which the local anesthetic is being deposited. Therefore even with tissues with low elasticity receive a constant pressure and rate of flow, resulting in a more favorable outcome. This has been demonstrated in a recent histological study reporting findings of minimal inflammatory changes when performing a PDL injection. The controlled rate of fluid administration also explains the reduced pain

perception noted by most patients during dental injections into tissues that typically elicit a high pain response. Many dentists have found that as a result of these unique characteristics of CCLADs, most traditional dental injection techniques can be performed with greater predictability and with less discomfort.

CCLAD technology has led to the development of two newly described nerve block techniques that recently have been reported in the dental literature. The anterior middle superior alveolar (AMSA) injection and the palatal approach-anterior superior alveolar (P-ASA) injection[22] have been described by Friedman and Hochman using the CCLADs. Both injections can be performed with a traditional syringe; however, the infusion characteristics and improved tactile control of a CCLAD system allow for more effective and comfortable drug administration. CCLADs allow local anesthetic 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 significant. The nasopalatine nerve block may be administered atraumatically in most patients. It is reasonable to conclude that any injection technique that has even a remote possibility of being uncomfortable to the patient can be delivered much more comfortable using a CCLAD device.[3]

Comfort Control Syringe[3]

Introduced several years after the Wand, the Comfort Control Syringe (CCS) system attempts to improve on the CCLAD concept. The CCS is an electronic, preprogrammed delivery system that provides the operator with the control needed to make the patient's local anesthetic injection experience as pleasant as possible. As with other CCLADs, this is achieved by depositing the local anesthetic more slowly and consistently than is possible manually. The CCS has a two-stage delivery system; the injection begins at an extremely slow rate to prevent the pain associated with quick delivery. After 10 seconds, the CCS automatically increases speed to the preprogrammed injection rate for the technique selected. There are five preprogrammed injection rates for specific injections. Standard dental local anesthetic cartridges and dental needles may be used in the CCS.

Advantages

1. Familiar "syringe" type of delivery system
2. Easy to see exactly how much local anesthetic solution has been dispensed, just like on a manual syringe.
3. Inexpensive disposables
4. All controls literally on your finger - tips.
5. Less costly than other CCLADs
6. Allows selection of various rates of delivery matched to the injection technique utilized.

Disadvantages

1. Requires additional armamentarium
2. More bulky than other computer-controlled or manual local anesthesia delivery devices.
3. More bulky than other computer-controlled or manual local anesthesia delivery devices.
4. Vibration may bother some users
5. Cost

Syrijet Mark Ii System

This instrument is manufactured by National Keystone, Cherry Hill, NJ, USA and was developed to achieve local anesthesia for dental procedures without the use of a needle. This is accompanied by delivering the anesthetic solution under high compressive forces.

Vibraject

A vibrating dental local anesthesia attachment has been introduced in recent years. This device was developed on the basis of the gate-control theory which states that pain transmission through A- delta and C nociceptive fibers is depressed at the secondary neuronal cell bodies in the dorsal horn if the nerve impulses evoked by tactile sensation are simultaneously transmitted through A delta fibers. It is therefore supposed that vibrating a needle with Vibraject can result in a reduction in injection pain. The manufacturer claims that the vibration reduces the patient discomfort of the patient markedly fears undergoing injection and also a state of the motor seems to have a calming effect and the need for topical anesthesia is eliminated. However, Yoshikawa *et al* reported that injection pain did not decrease when Vibraject was applied with a conventional cartridge type dental syringe with a 30 gauge needle.

Vibraject was not effective in reducing pain in children receiving local anesthesia. These results were consistent across child ratings of pain as well as both objective observations and subjective changes ratings of pain behaviour.[23]

Buffering Local Anesthetics In Dentistry

Introducing Carbon dioxide via the buffering process

Catchlove concluded that CO_2 in combination with Lignocaine HCl potentiates the action of Lidocaine HCl by (1) a direct depressant effect of the CO_2 on the axon (2) concentrating the local anesthetic inside the nerve trunk through ion trapping and (3)changing the charge of the local anesthetic inside the nerve axon. Condouris and Shakalis demonstrated that CO_2 possesses an independent anesthetic effect and caused a seven-fold potentiation in anesthetic action [24]

Computerized Delivery of Intrasulcular Anesthetics

CDS-IS is a safe, efficient and reliable technique to achieve adequate anesthesia in children's primary molars, primarily for amalgam, resin-based composite or stainless steel crown restorations. The effectiveness is not related to sex or to tooth location.[25]

Intraligamentary Anesthesia – Sta System

Milestone scientific corporation has a new single tooth anesthesia device. It has computerized control of flow rate of anesthetic delivery and the pressure applied when giving the injection.[26]

INJEX

Pediatric patients

Children are especially difficult dental patients because they are so very much afraid and cannot understand the purpose of the treatment. Experienced dentists are able to use INJEX to administer anaesthetic to all deciduous teeth (Körperich, 2002).

The shorter onset time (Saleh *et al*., 2002) also reduces the treatment-induced stress for children. Since only 0.3 ml of local anaesthetic is administered, the maximum dose is hardly ever used. Even very young children can be treated with INJEX (Körperich, 2002) who are especially pleased with the needle-free injection. The stress for accompanying parents is also reduced significantly due to the shorter treatment time. Small children are frequently less willing to cooperate with the dentist. This is where INJEX reduces the stress of administering a local anaesthetic due to the lower risk of injury. Patients usually continue to request anaesthesia with this system the next time they visit their dentist (Munshi *et al*., 2001; Grau *et.al*., 1997; Saravia *et al*.,1991).[27]

The Intraflow System (IntraVantage) is based upon a special low-speed handpiece with a clutch and foot pedal control system that permits perforation and injection with the hand piece in place, thus removing the need to switch from handpiece to syringe. The Intra flow handpiece system is about $900; the cost of disposable supplies is similar for all three systems, ranging from $1.50 to $2. Because intraosseous injections are into the highly vascular cancellous bone tissue space, use of vasoconstrictor-containing anesthetic agents is generally not advised due to the rapid uptake of the agent into the circulatory system with a subsequent increase in patient heart rate. In a number of studies, from 2 percent to 15 percent of patients reported moderate to severe pain during perforation, needle insertion, or injection of the anesthetic solution; and equal numbers of patients reported postoperative pain, swelling, or bruising at the injection site.[28]

Recent CCLADS are quick sleeper and anaeject. [29]

Syringe Micro Vibrator (SMV)

Upon mounting on a conventional dental anesthesia injection syringe, SMV is switched on and the clinician then uses normal injection technique to administer the anesthetic. It is more useful in pediatric patients.[30]

ORAQIX (a lidocaine and prilocaine periodontal gel) is packed into single use cartridges and applied directly into the pocket with a blunt tip applicator and its specially designed dispenser. It is not for injection. With a 30-second onset and 20 minutes duration, it can be applied to one or more periodontal pockets simultaneously.[31]

CONCLUSION

Dentistry is fortunate in that it possesses an abundance of excellent agents for the relief of perioperative and postoperative pain associated with the delivery of dental care.

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