

Newer Local Anaesthetic Drugs and Delivery Systems in Dentistry – An Update

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Abstract: Pain and its successful management have been one of the cornerstones of Dentistry worldwide since time immemorial. The successful use of local anesthetic solutions and their diligent administration have helped patients overcome their fears and displeasure towards dentistry. It is imperative on our part to update our knowledge and skills in using newer alternatives in pain control and management and ways of administering them to increase the comfort level of our patients and resolve the clichéd paradigm of “Pain and Dentistry are inseparable”. Lignocaine hydrochloride has been the gold standard in local anaesthesia and has proven its efficacy and efficiency to provide a pain free environment. However, newer drugs are currently available that overcome some of the potential drawbacks of Lignocaine and give us more focused relief in pain management. Similarly, the ‘dreaded injection from a dentist’ can be one of the primary reasons for potential patients not seeking timely treatment for their dental problems. To overcome this primary fear, many newer innovations in drug delivery systems have been devised to improve the patients’ experience at the dentist and thereby provide the dentist with a more cooperative patient, resulting in optimized dental care. This article reviews some of the alternatives to Lignocaine and also the newer drug delivery systems that have proven to be beneficial in providing optimal care to our patients.

Keywords: Local Anaesthetic drugs, Local Anaesthetic Reversal Agent, Local Anaesthetic Drug Delivery Systems

I. Introduction:

From the time of its discovery, local anesthesia has become an important part of the armamentarium of the clinician and they enjoy a unique place in dentistry as they have changed the emotional appeal of dentistry from being a painful and dreadful experience to being a less painful and pleasant experience.

The early history of local anesthesia speaks about two important discoveries:

1. *Braun’s* discovery – addition of adrenaline to the local anesthetic solution,
2. *Einhorn’s* discovery of Novocain [1].

These two discoveries helped in the development of regional anesthesia[1]. Regional anesthesia has facilitated the performance of many procedures in the specialty of Oral and Maxillofacial Surgery and Dentistry as chair-side procedures in the Dental Office.

In the recent years, advances in intravenous anesthetic techniques and the rising cost of hospital based services has helped promote the practice of “ambulatory anesthesia”[2]. Dental patients who benefit from office based anesthesia include those undergoing stressful procedures, fearful patients, medically and behaviorally challenged patients, young children and patients with a history of gagging or local anesthetic problems[2].

Regional Anesthesia has benefitted much from the introduction of newer drugs and anesthetic delivery systems. Lignocaine Hydrochloride has been the most commonly and widely used local anesthetic (LA) agent, and it is considered the ‘Gold Standard’ among LA drugs due to its proven efficacy, low allergenicity and least toxicity [3]. Two relatively new drugs that have proved to be equally or more efficient to Lignocaine are

1. Articaine[3, 4]
2. Centbuclidine [5]

1.1 Articaine: it belongs to the Amide group of local anesthetics. It consists of a thiophene ring instead of a benzene ring and an ester group that is metabolized by esterases in the tissues[4, 6, and 7]. Elimination of Articaine is exponential with a half-life of about 20 minutes. Metabolism is mainly in the liver and plasma by unspecified plasma esterases[8].

Articaine vs. Lignocaine:

1. Articaine has a faster onset of action[3]
2. Articaine has a longer duration of action[3]
3. Articaine has a higher success rate[3, 9]
4. Articaine has a greater potency (1.5 times more potent)[3, 8, 9]
5. Systemic intoxication of Articaine is lower[4, 6]
6. Articaine is a very safe drug[4]

The faster onset of action and longer duration of action of articaine are mainly founded on the notion that the thiophene ring bestows enhanced performance by increasing the lipid solubility and protein binding capacity of the drug[3, 7].

Lipid solubility and protein binding properties are intrinsic qualities of a local anesthetic drug molecule that aids in its penetration through the lipid nerve membrane and subsequent enhanced diffusion into the tissues including bone[3, 9 and 10]. Since, Articaine has a smaller pK value, it aids in its quicker disassociation leading to its shorter latency period in tissues and quicker onset of action [10]. This in turn reduces the number of repeat injections / volume of solution administered as compared to lignocaine 2% (1.7 times greater volume needed to that of 4% Articaine) for achieving the same anesthesia[3, 9].

One random double blind study conducted to compare four different local anesthetic solutions (2% lignocaine with 1:1,00,000 epinephrine, 4% Articaine with 1:1,00,000 epinephrine, 4% Articaine with 1:2,00,000 epinephrine and 3% Prilocaine with Felypressin) revealed that 4% Articaine with 1:1,00,000 epinephrine was the most effective solution[11].

According to FDA, the maximum recommended dose of Articaine 4% with 1:1,00,000 epinephrine is half the number of cartridges to that of lignocaine 2% with 1:1,00,000 epinephrine as each cartridge of Articaine has twice the amount of drug as that of lignocaine (72mg/cartridge-Articaine, 36mg/cartridge-lignocaine) [4]. Adverse effects of Articaine: Like prilocaine, Articaine also has potential to cause methemoglobinemia and neuropathies [8]. Paresthesia incidence is higher for articaine and prilocaine, mostly with the lingual nerve[6], suggesting greater neurotoxic effect of articaine as compared to lidocaine [10]. Ocular complications have been reported when using articaine especially for infra-orbital nerve block. This may be due to the increased diffusion of drug through the tissues including bone [10].

1.2 Centbucridine:

It is a local anesthetic molecule synthesized at the Centre for Drug Research of India at Lucknow, India in the year 1983[5]. It is a quinolone derivative with local anesthetic action [3,12]. It has intrinsic vasoconstricting and anti-histaminic properties. Centbucridine in a concentration of 0.5% can be used effectively for infiltration, nerve blocks and spinal anesthesia with an anesthetic potency 4-5 times greater than that of 2% lignocaine. [12]

A randomized double blind study compared the efficacy and tolerability of 0.5% Centbucridine with 2% lignocaine for dental extractions and the results revealed that the dose of analgesia obtained with Centbucridine compared well with that of lignocaine and it was well tolerated without any serious side-effects or significant changes in the cardio-vascular parameters [13].

Centbucridine has been tested successfully as a topical anesthetic in ophthalmic surgeries. Its topical anesthetic action is concentration dependent. It also demonstrates a longer duration of action and analgesic properties. [14,15]

This novel molecule has been extensively used in ophthalmology and other medical specialties, however, strangely the dental profession has failed to capitalize on its strengths and also validate its use in the management of pain in dental procedures. Currently, there is one study[13] of use of this drug in dentistry. More work is needed especially in Oral Surgery and Pedodontics.

1.3 Phentolamine: [3, 16] Drug used for Reversal of effects of local anesthetic solutions

The functional deficits resulting from local anesthetic solution containing a vaso-constrictor after the completion of the procedure is an indication for the reversal of soft tissue anesthesia (lip & tongue numbness). Phentolamine Mesylate[Fig. 1] is one drug which is indicated for this purpose. It is a non-selective alpha adrenergic blocking agent and reverses the effects of epinephrine and nor-epinephrine on tissues containing the alpha one and alpha two adrenergic receptors. The ultimate effect of alpha receptor blockade is vaso-dilatation. It is presumed that the vaso-dilatation produced due to the alpha adrenergic block results in a rapid distribution of local anesthetic solution away from the injection site. Peak concentration is achieved after 20 minutes and the elimination half-life is 2-3 hours.

Adverse reactions such as diarrhea, facial swelling, hypertension, jaw pain, oral pain, injection site reactions, tenderness and vomiting have been reported. Majority of the adverse reactions are resolved within 48 hours. Administration of this drug should be done with caution in patients with cardiovascular disease and stroke.

It is available as a cartridge with a concentration of 0.4mg/1.7ml. The recommended dose is based on the number of cartridges of local anesthetic with vaso-constrictor administered. One cartridge of reversal agent is required for every cartridge of local anesthetic solution given. It is administered following dental procedure using the same location and techniques (infiltration / block injection) employed for the administration of local anesthetic solution. It can be used in all patients above 6 years of age, in pediatric patients weighing 15-30kgs the maximum recommended dose is 0.2mg of phentolamine (half a cartridge). After administration the patient is counseled not to eat / drink until normal sensation returns.

This novel molecule is a recent innovation in reversal of local anesthesia that will immensely benefit child patients and others with special needs to prevent post-operative anesthesia induced injuries.

II. Newer Drug Delivery Systems for Dental Local Anesthesia

Effective delivery of local anesthesia is one of the keystones of modern dental practice. The injection of LA is also the greatest source of fear and the inability to obtain adequate pain control with minimal discomfort remains a significant concern for dental practitioners worldwide. Development of newer technologies has provided enhanced pain relief with diminished pain from injection and fewer side effects. The advances are [3, 17]:

1. Electronic Dental Anesthesia – EDA[Fig 02]
2. Intra-oral Lignocaine Patch- Dentipatch[Fig 03]
3. Jet Injection[Fig 04]
4. Iontophoresis[Fig 05]
5. EMLA[Fig 06]
6. Computer Controlled Local Anesthetic Delivery Devices – CCLAD[Fig 07],[Fig 08], and [Fig 09]
7. Intra-osseous Systems – IO Systems[Fig 10]

1.1 Electronic Dental Anesthesia: this technique involves the use of the principle of Transcutaneous Electrical Nerve Stimulation (TENS) which has been used for the relief of pain. It can be used a supplement to conventional local anesthesia. Some limitations of this technique are increased salivary flow and inability to use metal instruments freely. It is contraindicated in several conditions such as heart disease, seizures, neurological disorders, brain tumors, patients wearing pacemakers and cochlear implants.

1.2 (Dentipatch): a patch that contains 10-20% lidocaine is placed on the dried mucosa for 15 minutes. Hersh et al (1996) studied the efficacy of this patch and recommended it for use in achieving topical anesthesia for both maxilla and mandible.

1.3 Jet Injection: in this technique a small amount of local anesthetic is propelled as a jet into the sub-mucosa without the use of a hypodermic syringe/needle from a reservoir. This takes place when the knob is pressed to release air pressure which produces a fine jet of solution which penetrates the mucosa through a small puncture wound to produce surface anesthesia. This technique is particularly effective for palatal injections.

1.4 Iontophoresis: This technique first introduced in 1993 is a suitable alternative for application of drug in achieving surface anesthesia. It is a painless modality of administering anesthesia. Initial reports have shown an encouraging response from patients; however, further research is warranted.

1.5 EMLA – Eutectic Mixture of Local Anesthetics: It contains a mixture of lignocaine and prilocaine bases, which forms an oil phase in the cream and passes through the intact skin. Clarke et al in 1986 suggested the use of EMLA cream for anesthetizing the skin prior to needle insertion as this reduces the incidence of injection pain.

1.6 CCLAD Systems (Computer Controlled Local Anesthesia Delivery System): ‘Milestone Scientific’ introduced the first CCLAD system in 1997 and was termed the “WAND” and the subsequent versions were renamed as “WAND PLUS” and “COMPUDENT”. In 2001, DENTSPLY International introduced the “Comfort Control Syringe – CCS” and similar devices originating outside USA were; “Quick Sleeper, Sleeper One from France, “Anaject” and “Orastar” from Japan.

1.6.1 “Wand” has 3 components: Base unit, Foot pedal and Disposable Handpiece assembly. Base unit consists of a microprocessor and connects to the foot pedal and Handpiece assembly that accepts the LA cartridge. LA solution from the cartridge passes through the microbore tubing in the Handpiece assembly and attached needle into the target tissue.

Rate of Injection: foot pedal controls the rate of injection and if aspiration feature is enabled, it prevents inadvertent intravascular injections.

1. Slow: 0.005ml/s – needle insertion, PDL injection, Palatal administration
2. Fast: 0.03ml/s – buccal infiltrations, nerve block
3. Turbo: 0.06ml/s

1.6.2 “Single Tooth Anesthesia System – STA System” was introduced by Milestone Scientific in 2007. Its advantages include ‘Dynamic Pressure Sensing – DPS’ which provides continuous feedback to the user about the pressure at the needle tip to identify the ideal needle placement for PDL injections.

Rate of Injection: 3 modes to control the rate of injection

1. STA mode: Single, slow rate of injection
2. Normal mode: emulates the Compudent device
3. Turbo mode: faster rate of injection – 0.06ml/s

1.6.3 “Comfort Control Syringes” consists of two components; base unit and syringe. The most important functions of the unit (injection and aspiration) can be controlled directly from the syringe.

Rate of injection: Five different basic injection rate settings for specific applications: block, infiltration, PDL, IO and Palatal regions. The unit uses two stage delivery rates for every injection. It initially expresses the LA solution at an extremely low rate and after 10 seconds the rate slowly increases to the pre-programmed value for the selected injection technique.

Advantages of CCLADs: The benefits of these devices is attributed to

- 1) Ability to administer small quantities of LA solution continuously during needle insertion, which anesthetizes the tissue immediately ahead of the advancing needle.
- 2) Steady infusion of the anesthetic solution at the target site reduces the discomfort associated with less controlled injections. Other advantages include:
- 3) More accurate needle insertion
- 4) Less pain on injection
- 5) Less fear of injection
- 6) More controlled insertion of the needle
- 7) Ability to rotate the Handpiece back and forth during needle insertion to avoid needle deflections & reduced force for insertion leading to more comfort for patients.
- 8) Ability to perform newer techniques such as
 - a. AMSA – anterior middle superior alveolar block
 - b. PDL – periodontal ligament infiltration
 - c. P-ASA – palatal approach to anterior superior alveolar block.

Because of these attributes the CCLAD devices are better tolerated by patients and produce less disruptive behavior can be used successfully for restorations, pulpal therapies & extractions in pediatric dentistry.

1.7 Intra-Osseous Anesthesia: the use of motor driven perforator to penetrate the buccal gingiva and bone can be considered as the first modern technique of IO anesthesia. The devices used for this technique, inject the solution into the cancellous bone adjacent to the root apex. Commonly used devices are:

- i. Stabident
- ii. X – Tip
- iii. Intraflow

1.7.1 Stabident: it includes a solid 27 gauge perforator needle with a beveled tip and a plastic base which fits a latch type slow speed contra-angle handpiece. This perforator creates a small tunnel through attached gingiva, periosteum and alveolar bone. The insertion point of the perforator is in the attached gingiva, 2mm below the facial gingival margin and midway between the tooth of intent and immediately adjacent (distal) tooth. The angle of perforation is not critical and is usually directed apically in the mandibular incisor region whereas a more perpendicular angle is advantageous in the molar region to avoid bending the perforator against the dense cortical bone. Later a 27 gauge ultra-short needle is used to deposit the local anesthetic solution.

1.7.2 X – Tip: this system consists of three parts; the drill/perforator, 25 gauge guide sleeve that fits over 27 gauge drill and ultra-short 27 gauge needle. The advantage of this system over Stabident is the ease with which the perforation could be located for inserting the needle. The drill leads the guide sleeve through the cortical plate into the cancellous bone. The drill portion is removed, leaving the guide sleeve in place, which directs the needle into the cancellous bone to deposit the LA solution. Later the guide sleeve is removed with a hemostat.

1.7.3 Intraflow: the Intraflow HTP Anesthesia Delivery System is an “all in one” system that allows the operator to perforate the bone and deposit the anesthetic solution in a single step. The device is a dental handpiece equipped with an injection system built into its body. A 24 gauge hollow perforator is used to penetrate the bone and infuse the LA solution. The anesthetic solution from the cartridge is routed to the perforator by a disposable transfuser that also serves to cover the switch used to select between the perforator rotation and anesthetic infusion modes. Penetration with this low speed high torque device is by a single, steady insertion using direct pressure.

2.8 Clinical uses of IO Anesthesia: most common application is for Single tooth anesthesia. It can also be used as a primary method of pain control or as a supplementary technique in refractory cases. These systems help to achieve profound anesthesia in cases of irreversible pulpitis of lower molar teeth. It also helps in treating children and adolescents due to its quick onset of action, limited duration and minimal collateral anesthesia.

2.9 Side effects and Complications of Intra Oral Anesthesia:

1. Tachycardia, hence this should be avoided in patients at risk of cardiovascular disease particularly when used with a vaso-constrictor.
2. Separation of perforator drill / needle from its plastic holder. This happens when the perforation is difficult or the drill heats up from overuse. When broken, the shaft of perforator should be held with a small hemostat and retrieved.
3. Placement of a gauze barrier is indicated when removing the shaft or an X-Tip guide sleeve to avoid the possibility of ingestion or aspiration of foreign body.
4. Overheating of bone and macerating of overlying soft tissue may cause pain, swelling and localized injections
5. Post injection hyper-occlusion, pain and chewing soreness are other symptoms reported.
6. Dentinal tooth damage and osteonecrosis of bone may rarely occur after IOA injection.

III. Conclusions:

Local anesthesia has been the cornerstone of modern day pain-free dental practice. However, the practitioners' limitations in updating about newer drug formulations available and newer techniques to administer the drugs has, still not made the goal of pain-free dentistry a reality. The availability and cost factors are not excuses not to adapt newer proven methods, when the benefits outweigh the shortcomings. There is a need in the current evidence-based era of dental practice for us to constantly update, evaluate and incorporate newer drugs and techniques into daily practice to provide our patients the best of care at all times.

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Figures



Fig 1 - Phentolamine - LA Reversal Agent



Fig 02 - Electronic Dental Anesthesia



Fig 03 - Intraoral Lignocaine Patch



Fig 04 - Jet Injection



Fig 05–Iontophoresis



Fig 06– EMLA (Eutectic Mixture of local anesthesia)



Fig 07– CCLAD (computer controlled local anesthesia delivery systems)– WandDevice



Fig 08 - CCLAD - Single tooth Anesthesia



Figure 1: Comfort Control Syringe by DENTSPLY International.

Fig 09 - CCLAD - Comfort control Syringe System



Figure 2. Intraosseous Delivery System

Figure 3. Intraosseous Delivery System



Figure 4. Intraosseous Delivery System

Fig 10 - Intra Osseous delivery systems