Local anaesthetics in dentistry - Part 2: Choice of local anaesthetic agent

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Currently, in general dentistry the most commonly used local anaesthetic agents are 2% lignocaine (Xylotox, Adcock Ingram; Xylesthesin, 3M) with 1:80000 adrenaline content, 3% mepivicaine (Carbocaine) without a vasoconstrictor and 4% articaine (Ubistesin 3M) with either 1:100000 or 1:200000 adrenaline concentration.

The local anaesthetic molecule consists of three components: (a) lipophilic aromatic ring, (b) intermediate ester or amide chain, and (c) terminal amine.[1] The aromatic ring improves lipid solubility.[1–3] The nerve membrane consists of a double lipid layer and a protein layer and therefore the property of enhancing lipid solubility contributes to increased potency of the anaesthetic agent as more of the available drug can diffuse through the membrane. The benzene aromatic ring is replaced in articaine by a thiophene ring, which allows even greater lipid solubility and further penetration of an administered dose into the neurons. Local anaesthetics have protein-binding characteristics which determine the duration of anaesthesia. Affinity for plasma proteins corresponds to affinity for protein at the receptor site within sodium channels, prolonging the presence of the anaesthetic at the site of action. Agents that attach to the protein components of nerve membranes are also less likely to diffuse from the site of action and enter the systemic circulation, and therefore pose a lower systemic toxicity risk.[2,5]

The intermediate chain can be either an amide or ester group; in general ester -containing local anaesthetic solutions are no longer packaged in dental cartridges.[3] However, articaine is unique in this regard. It is classified as an amide according to its intermediate linkage, but also contains an ester side chain on its aromatic ring.[1,2,6] It is the only amide anaesthetic containing an ester group, allowing hydrolysis by blood cholinesterase (biotransformation in the plasma) as well as in the liver (by hepatic microsomal enzymes).[1–3,6] As a result, articaine has a half-life of only 20 minutes compared with 90 minutes for lignocaine that requires total hepatic clearance.[3] Hence, articaine presents less risk for systemic toxicity during lengthy appointments when additional doses of anaesthetic are administered.[2,3]

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DOSAGE OF LOCAL ANAESTHETIC

Dental cartridges generally contain two drugs, namely, a local anaesthetic and a vasoconstrictor, each having its own dose limitations. Serum concentrations are related to the total dosage rather than the concentration of the solution, e.g. 2% or 4% local anaesthetic. Administering 20ml of 2% or 10ml of 4% (400mg) produces the same serum concentration.[2,3] Thus it is important to consider the dosage (milligrams) administered and not the volume (milliliters or cartridges) of the local anaesthetic administered. One should consider anaesthetic cartridges as containing 2ml and not 1.8ml to simplify calculations, leading also to an overestimation of the dosage, thereby promoting safety in limiting administration of the drug. Lignocaine 2% contains 36mg and articaine 4% contains 72mg of the drug per cartridge.

Each local anaesthetic has its own maximum recommended dose (MDR), expressed in mg/kg. Unfortunately, the mg/kg MDR for each drug varies in the literature[7] from 4.4mg/kg[8] to 6.6mg/kg.[9] Recommended maximum doses for healthy adults (Table 1) for lignocaine 2% is 4.4mg/kg, for articaine 7mg/kg and for mepivicaine 6mg/kg with a ceiling dose approximate to those for a 70kg person.[8,10]

Thus, the MDR of 2% lignocaine with adrenaline for a 15kg child = 15kg x 4.4mg/kg = 66mg maximum dose of lignocaine. Since a lignocaine/cartridge contains 36mg of the drug this equates to 1.5 cartridges.[7] A general conservative "rule of 10" may be used as a general guideline for maximum dosages i.e. one cartridge per 10kg body weight (up to a maximum of 70kgs). Thus, the MDR for a 15kg child would be 1.5 cartridges lignocaine.

CLINICAL EFFICACY OF ARTICAINE VERSUS LIGNOCAINE

There seems to be conflicting research results regarding the advantage of 4% articaine over 2% lignocaine. It is difficult to demonstrate to a level of statistical significance (evidence-based medicine) in a clinical trial that 4% articaine is superior to any other amide local anaesthetic.[11]

However, anecdotal reports claim that articaine

1. works faster,
2. works better,
3. "I don't miss as often," and
4. "gets patients numb when other local anaesthetics fail."[11]

Table 1: Dosages of local anaesthetic and adrenaline.

Local anaesthetic agent	Concentration of local anaesthetic	mg/cartridge (1.8ml) local anaesthetic concentration	Maximum dose in mg	Maximum dose in mg/kg	Concentration of adrenaline	mg/cartridge (1.8ml) concentration of adrenaline
Lignocaine	2%	36mg	300mg	4.4mg/kg	1:80000	0.023mg
Mepivicaine	3%	54mg	300mg	6.0mg/kg	-	-
Articaine	4%	72mg	500mg	7.0mg/kg	1:100000	0.018mg
Articaine	4%	72mg	500mg	7.0mg/kg	1:200000	0.009mg

2% lignocaine and 4% articaine with 1:100000 adrenaline have similar properties for use in surgery and have demonstrated a good safety and tolerance profile.[12]

On the other hand, articaine with 1:100000 adrenaline showed a higher success rate than lignocaine with 1:100000 adrenaline for buccal infiltration of mandibular molars[13,14] but not when administered in the attempt to anaesthetize teeth with irreversible pulpitis.[15] The efficacy of 4% articaine with 1:100,000 adrenaline was similar to 2% lignocaine with 1:100,000 adrenaline for intra-ligamentary injections.[16] In a study on patients with irreversible pulpitis the anaesthetic efficacies of articaine and lignocaine were similar for inferior alveolar nerve blocks.[17–19]

However, other studies have shown that infiltrations of 4% articaine with adrenaline offer better clinical performance than 2% lignocaine in terms of latency and duration of the anaesthetic effect, but have not demonstrated any statistically significant differences in anaesthetic efficacy.[13,20] When the success of inferior alveolar nerve blocks were compared, articaine and lignocaine performed similarly.[21] For infiltration articaine produced shorter onset and longer duration of pulpal anaesthesia than the lignocaine solution.[22] Supplemental buccal infiltration with articaine was more effective than lignocaine in mandibular molars with irreversible pulpitis.[23] This may be the result of a concentration effect or a greater diffusion of articaine. There was a high statistically significant difference between the articaine and lignocaine solutions when their efficacy was compared in maxillary buccal infiltrations in patients with irreversible pulpitis.[24] The success of articaine after infiltration may be attributable to high lipid solubility and more molecules/ml injected when compared with lignocaine.[3] For patients undergoing periodontal surgery, 4% articaine anaesthetic with 1:100000 or 1:200000 adrenaline provides excellent surgical pain control.[25]

In a systematic review articaine was shown to be more effective than lignocaine in providing anaesthetic success in the first molar region. The drugs appear to have similar adverse effect profiles.[26,27] Another meta-analysis study concluded that articaine had a probability of achieving anaesthetic success superior to that of lignocaine, with an odds ratio of 2.44 (95% confidence interval [CI], 1.59–3.76; $P < 0.0001$).[28] The odds ratio for articaine increased to 3.81 (95 % CI, 2.71–5.36; $P < 0.00001$) when the authors analysed only the data for infiltration. There was weaker, but still significant, evidence of articaine being superior to lignocaine for mandibular block anaesthesia, with an odds ratio of 1.57 (95% CI, 1.12–2.21; $P = 0.009$).[28]

SAFETY OF 4% LOCAL ANAESTHETIC

The apprehension that 4% articaine is related to adverse neurological effects like paraesthesia seem to stem from a retrospective study by Haas and Lennon.[29,30] These authors reported that generally the incidence of paraesthesia is low but if paraesthesia does occur, it is significantly more likely to do so if either 4% articaine or prilocaine[31,32] has been injected. Hence, it has been suggested that the use of these agents for infiltration be limited and to rather reserve their use in nerve blocks for failed attempts with other agents.[2,3]

Allegations that 4% local anaesthetics are associated with a greater risk of paraesthesia are based solely on anecdotal reports and have no scientific justification.[6,11] Linking 4% local anaesthetic with an increased risk of neurotoxicity, and recommending that the use of articaine be avoided in mandibular nerve blocks is unjustified. Articaine is in fact a “safe and effective local anaesthetic” for Dentistry.[11] To date, there has been no explanation that an inferior alveolar nerve block can, on a rare occasion, cause permanent nerve injury.[33] Articaine is a safe and effective local anaesthetic drug to use in Dentistry.[4,6]

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