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Local Anaesthesia: Risks and Controversies

Abstract: This paper describes the complications that can occur as the result of the intra-oral injection of local anaesthetics. It considers important localized and systemic complications and describes strategies to limit the occurrence of such problems.
Clinical Relevance: Local anaesthetics are routinely administered during many dental procedures. An understanding of the risks involved in these injections is important.
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Local anaesthetics are the most commonly administered drugs in dental practice. They have an amazing safety record. Most side-effects are minor and reversible.[1] Nevertheless, some serious unwanted outcomes may ensue after the intra-oral injection of a local anaesthetic. This paper describes such effects and suggests strategies to minimize these events.

Unwanted effects

Unwanted effects may occur as the result of the following:

- Injecting an inappropriate solution;
- Injecting too much solution;
- Injecting into the wrong site;
- Bad luck.

Each of these will be considered. The most serious adverse effects are central nervous system problems as a result of overdose or intra-arterial injection and long-standing nerve problems after regional block anaesthesia.

Injecting an inappropriate solution

The only absolute contra-indication to the use of a local anaesthetic in an individual is allergy to that solution. Allergic reactions to amide local anaesthetics are very rare indeed.[2] All of the injectable local anaesthetics used in the United Kingdom are amides. Allergy to esters is more common. The only ester local anaesthetics commonly used are the topical agents benzocaine and amethocaine. The other agent that may cause an allergic reaction during injection of a dental local anaesthetic is latex, which is used in the manufacture of some cartridges. Fortunately, latex-free cartridges, such as Septanest (articaine with adrenaline, Septodont, Kent, UK) and recently manufactured Citanest (prilocaine with octapressin, Dentsply, Surrey, UK) are available. If a dentist is unsure as to the status of a cartridge, the manufacturer should be contacted as some older cartridges may not be latex-free. If a patient gives a history suspicious of an allergic reaction, such as the development of a rash or breathing difficulties, they should be referred for allergy testing to determine if an allergy exists and also to establish a suitable alternative drug.

Some patients seem to have a genuine supersensitive reaction to

Local anaesthetic	Maximum dose (mg/kg)	Amount (mg) in 1/10 1.8ml cartridge	Amount (mg) in 1/10 2.0ml cartridge	Amount (mg) in 1/10 2.2ml cartridge
2% lidocaine	4.4	3.6	4.0	4.4
2% mepivacaine	4.4	3.6	4.0	4.4
3% mepivacaine	4.4	***5.4***	***6.0***	***6.6***
3% prilocaine	6.0	5.4	6.0	***6.6***
4% prilocaine	6.0	***7.2***	***8.0***	***8.8***
4% articaine	7.0	***7.2***	***8.0***	***8.8***

Values in bold italics show where 1/10th of a cartridge is greater than the recommended maximum dose per kilo. The ceiling doses approximate to those for a 70 kg subject.

Table 1. Recommended maximum doses for the solutions used in dental practice in the United Kingdom.

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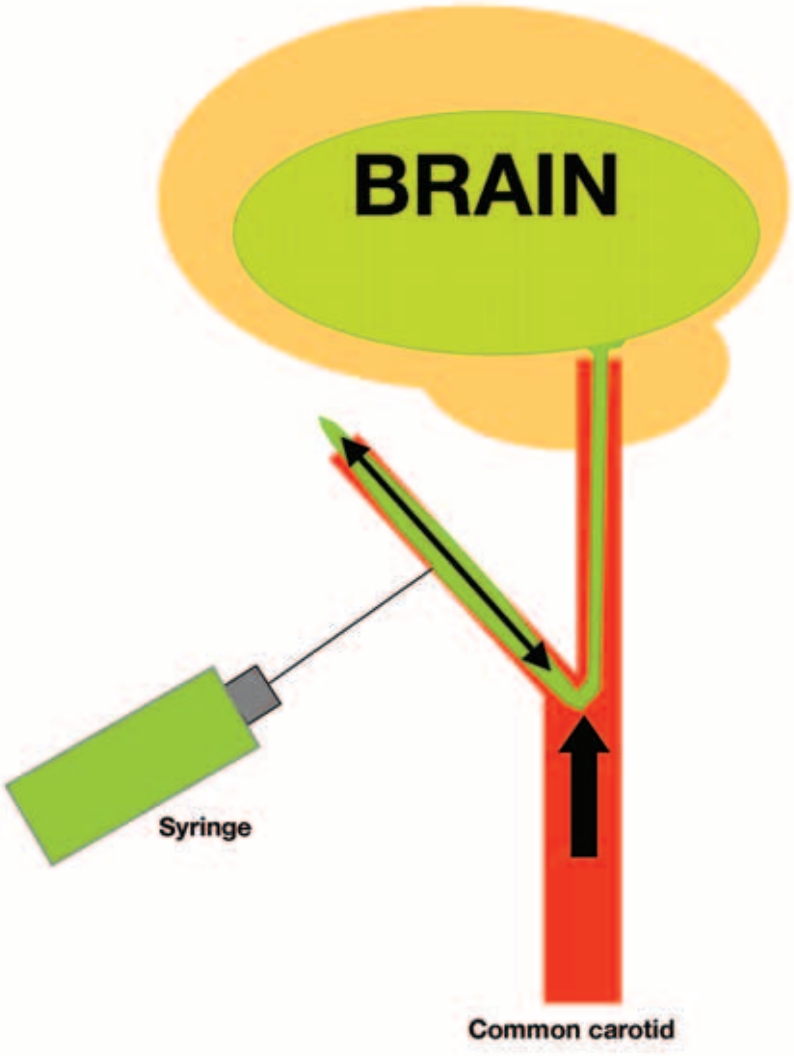

Figure 1. The mechanism of reverse carotid flow. Injection under strong pressure into a branch of the external carotid artery can cause some local anaesthetic solution to flow to the carotid bifurcation, where a portion can be redirected to the brain via the internal carotid artery.

adrenaline-containing local anaesthetics and experience tachycardias after injection. If a patient reports this, it is wise to avoid the use of an adrenaline-containing solution.

Injecting too much solution

Overdose of local anaesthetics leading to toxicity is possible. This is particularly the case in children as the toxic dose is weight related. Table 1 gives recommended maximum doses for the solutions used in dental practice in the United Kingdom and also shows how much is in 1/10th of a cartridge of each solution. A guideline of 1/10th of a cartridge per kilogram is a useful rule of thumb as a maximum dose.

The organ that usually suffers during a local anaesthetic overdose is the brain. Central nervous system tissue is more susceptible to the actions of local anaesthetics than peripheral sensory nerves. The early signs of toxicity are excitability as the inhibitory actions of the brain are the first to be depressed. This is followed by signs of central nervous depression that can lead to unconsciousness. If very large doses are administered, death can ensue because of respiratory depression. It must be remembered that the effects of different local anaesthetics are cumulative. It is therefore not possible to change to another local anaesthetic after the maximum dose of one has been given. So, the 1/10th of a cartridge per kilo guideline is useful to determine the safe maximum dose when different solutions are combined.

Injecting in an inappropriate site

There are three sites of injection that can cause problems. These are:

- Intra-arterial;
- Intravenous;
- Intraneural.

Intra-arterial injection

Injection of local anaesthetic solution into an artery is not as common as deposition intravenously. Contact with an artery may produce discomfort as the artery may go into spasm and a localized area of blanching may be noted. The main problems with intra-arterial injection are delivery of local anaesthetic solution directly into the central nervous system or interfering with special senses. Sight can be affected. Double vision may occur if the orbital muscles are affected and permanent loss of sight has been reported.[3] This latter effect may occur as a result of occlusion of the retinal artery or introduction of emboli into the ophthalmic artery. Hearing loss following local anaesthesia may occur either as a result of CNS toxicity or ischaemia of the cochlea following intravascular injection.[4] The most dramatic effect on the central nervous system is hemiparesis of the body. This may be the result of reverse carotid flow of solution.[5] In this scenario, local anaesthetic is injected into a branch of the external carotid artery and, if excess force is employed, solution travels against arterial flow to reach the carotid bifurcation where some is then redirected to the brain via the internal carotid artery. This is illustrated in Figure 1.

Intravenous injection

Injection of solution into a vein is a real possibility during the administration of intra-oral local anaesthesia. An indication as to the likelihood can be gauged by examining studies that have investigated the number of positive aspirates during intra-oral local anaesthesia. In some studies, positive aspirates have been obtained in over 20% of inferior alveolar nerve blocks.[6-8]

The danger of intravenous

injection is the production of systemic effects caused by the local anaesthetic or vasoconstrictor, such as adrenaline. These include CNS toxicity and effects on the heart, such as tachycardias and arrhythmias.

Intraneural injection

Injection into a nerve trunk can cause damage, both as the result of needle trauma, and by physical and perhaps chemical damage resulting from the dispersal of solution into the nerve bundle. This can lead to:

- Long-term anaesthesia (lack of sensation);
- Paraesthesia (altered sensation such as 'pins and needles');
- Dysaesthesia (pain).

Unfortunately, dysaesthesia is more likely following local anaesthesia than surgery.[9]

Bad luck

As well as the problems produced by intravascular injection mentioned above, it is possible to penetrate both sides of a blood vessel, especially during deep injections such as inferior alveolar nerve blocks. This may cause bleeding. If this affects a muscle such as the medial pterygoid, then post injection trismus may ensue. There is nothing that can be done to prevent such a complication when regional blocks are administered.

It is possible to contact a nerve either in the approach or withdrawal from the site of anaesthetic deposition. The patient may often react when this happens and, if this is noted, then solution should not be deposited at that site. Nevertheless, the fact that nerves can be traumatized by the needle means that such a possibility can occur even when technique and equipment are excellent and, like the penetration of blood vessels mentioned above, this is probably an unavoidable consequence of regional block techniques. It has been estimated that every dentist will have one patient who suffers permanent damage to a nerve following an inferior alveolar nerve block and that there is no means of prevention.[10]

Strategies to reduce complications

Reducing toxicity

The suggestion of using the guideline of 1/10th cartridge per kilo as a rough guide to the maximum dose was mentioned earlier. As shown in Table 1, this is not an absolute rule but it is a helpful approximation, especially when using combinations of different local anaesthetics in the same patient.

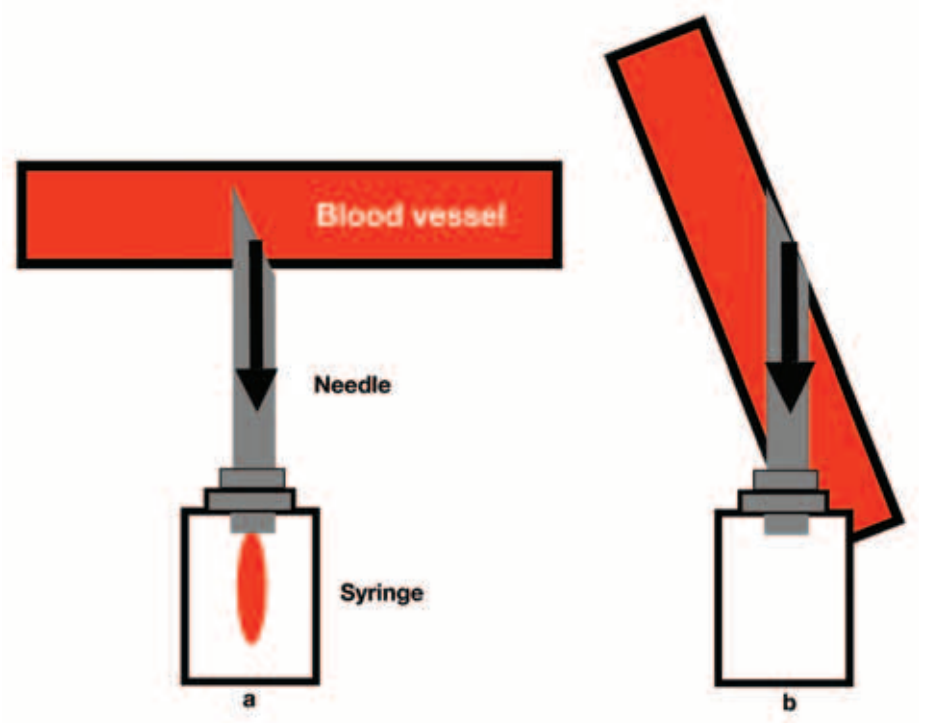

Figure 2. (a) Aspiration occurs when the tip of the needle is in a blood vessel. **(b)** Aspiration may fail if the needle is blocked by the wall of the blood vessel.

Reducing systemic effects

A good medical history, including a comprehensive drug history, must be taken to avoid systemic effects such as an allergic reaction, drug interaction, or unwanted effect of adrenaline. The best way to avoid injecting into a blood vessel is to use an aspirating syringe system. The use of non-aspirating syringes cannot be supported.

Reducing CNS effects

In order to avoid injecting into an artery that supplies the CNS, an aspirating syringe system should be used. Aspirating systems are not infallible and can fail in a number of ways. These include equipment defects. However, even with properly functioning equipment, it is possible that aspiration may not be successful. A possible scenario is illustrated in Figure 2, which demonstrates blockage of the needle by the vessel wall preventing aspiration. As this is a possibility, a slow injection technique should be employed as this will prevent retrograde flow of solution.

Reducing nerve injury

The best way to prevent nerve injury is to avoid regional block injections. If a regional block, such as an inferior dental nerve block injection, is given then note must be made of any electric shock type sensation the patient may feel. If this occurs, no solution should be injected at that point but the needle should be moved a few millimetres away before injecting.[11] It is perhaps surprising to note that intraneural injection does not always produce pain and does not always cause nerve injury.[12] Around 8% of inferior alveolar nerve blocks produce an electric shock type sensation and it has been suggested that 15% of this group experience long-lasting altered sensation of varied duration.[13] It has been noted, however, that 57% of patients suffering from prolonged altered sensation did not experience 'electric

shock' at the time of injection.[10] It has been suggested that any problem caused by needle trauma should recover within two weeks of injection in around 80% of patients.[14] Another point worth noting is that slow injection is helpful in reducing damage to the nerve. It has been demonstrated that nerve damage is more common when local anaesthetics are injected under pressure.[15] Similarly, it has been suggested that, if pressure is required to inject, then this could be a sign of intraneural injection.[16] If such an increase in pressure is felt during injection, it is wise to reposition the needle.

There are a number of other advantages to injecting slowly. There is less discomfort to the patient during infiltration and regional block injections.[17,18] In addition, slow injection has been shown to increase the efficacy of inferior alveolar nerve blocks.[18] Furthermore, it is reasonable to suppose that slow injection will reduce systemic effects as adverse effects may be noted before large doses are administered. It is also probable, as mentioned above, that slow injection should minimize the possibility of reverse carotid flow. Thus there is little to argue against slow injection. A rate of 30 seconds per ml of solution is recommended.

Whether or not the choice of solution, particularly with respect to anaesthetic concentration, affects the chances of nerve damage is an area of controversy. The concentration of the local anaesthetic is certainly related to the survival of nerves *in vitro*; the higher the concentration the lower the cell survival.[19] There are reports that nerve damage is more common after the use of 4% compared to 2% solutions,[20,21] however, some dispute the scientific design of those studies.[22] Malamed,[23] quoting the European Pharmacovigilance committee, states that there is no contra-indication to the use of the more concentrated solutions for regional block anaesthesia.

The nerve that is usually damaged during inferior alveolar nerve block injections is the lingual nerve. This accounts for 70% of the damage.[10] One suggestion is that this is more likely the result of trauma, and that over-reporting of such injuries happens when a new drug formulation, such as 4% articaine, is introduced. There is another explanation why the lingual nerve is more likely to suffer damage. This relates to its structure. At the region of the lingula the lingual nerve is composed of very few fascicles and, in some individuals, it is unifascicular at this point.[9] This is unlike the inferior alveolar nerve, which is multifascicular in this region. This structural difference may explain why the lingual nerve is more susceptible than the inferior alveolar nerve to injection damage.

An important question is, should the more concentrated local anaesthetic solutions, such as 4% articaine, be used for inferior alveolar nerve blocks? The incidence of iatrogenic nerve damage after inferior alveolar nerve blocks is about 1:500,000, so the risk is low. If there are advantages to the use of the more concentrated solutions for inferior alveolar nerve blocks, then the benefit probably outweighs any risk of nerve damage. Although 4% articaine has been shown to be more effective than 2% lidocaine in mandibular infiltration anaesthesia,[24,25] there is no published evidence that the former is more effective during inferior alveolar nerve block injections. Until such benefit is proven, there appears to be no advantage in using the more concentrated solutions for such a technique.

As mentioned above, it is the painful dysaesthesia that can result from injection damage. Another unfortunate aspect is that damage resulting from injection is less amenable to surgical repair than surgical damage.

The only way to ensure that nerve damage is not produced is to avoid regional block injections. There are many other techniques, such as intraligamentary and intra-osseous injection, that can be used as alternatives. These, however, have their complications, such as damage to the periodontium. There has been resurgence in interest in infiltration anaesthesia in the mandible as a consequence of the introduction of 4% articaine. A couple of recent studies[26,27] have suggested that infiltration of 4% articaine in the mandibular molar region can obtain anaesthesia of the lower first molar that is as effective as an inferior dental block. Thus it is ironic that 4% articaine, the drug that has caused such controversy concerning nerve damage, may be helpful in preventing this complication.

Conclusion

In conclusion, the best way to avoid problems is to take (and take heed of) a good medical history, use an aspirating syringe, limit the use of regional block anaesthesia and inject the appropriate solution slowly.

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