Local and regional anesthetic and analgesic techniques in the dog and cat: Part I, pharmacology of local anesthetics and topical anesthesia

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Introduction

Although the use of general anesthesia has decreased the need for local analgesics in dogs and cats, there is still a place for such techniques in small animal general practice. As well as enabling simple procedures to be performed in conscious or sedated animals, local or regional blockade of nerves can provide additional analgesia during the perioperative period. This article describes some of the commonly used analgesic techniques that can be performed in everyday practice.

Pharmacology of local anesthetics

Local anesthetics prevent the rapid influx of sodium ions into nerve axons, which produce an action potential and propagate nerve transmission. As there are many different types of sodium channels in different tissues, the anesthetic effects of different drugs can vary. There is also a difference in the sensitivity of different types of nerve fiber to blockade. Preganglionic sympathetic nerve fibers (B fibers) are more sensitive to blockade than are large A-motor fibers, and the ability of local anesthetics to block pain-transmitting C-fibers lies somewhere between that of A- and B-fiber blockade.

Based on chemical structure, local anesthetic drugs are classified as belonging to either the ester or amide groups. Drugs in the ester family include procaine and benzocaine; amide-linked local anesthetics include lidocaine, mepivacaine, and bupivacaine. The potency of local anesthetics is linked to the degree of lipid solubility, and the speed of onset of action is thought to be linked to the acid-dissociation constant (pKa). The uncharged base form readily crosses the nerve sheath; therefore, formation of more base increases speed of onset of action. This is why some reports document adding bicarbonate to increase the time to onset of the block. Since the site of anesthetic action involves the protein structure of the nerve axonal membrane, the duration of action of local anesthetic drugs is linked to their level of protein binding.

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Pharmacokinetics

Distribution of the drug around a nerve depends on the volume used, while penetration of the nerve fiber depends on its concentration. Therefore, diluting the local anesthetic solution will increase the volume that can be injected without exceeding toxic levels of the drug, but the quality of blockade may be affected.

Most local anesthetics are injected around nerve fibers and the duration of contact of the drug with the nerve trunk depends on the vascularity of the tissue. The greater the blood flow through the area of tissue, the faster the drug will be absorbed into the systemic circulation. To prolong the length of action of a local anesthetic drug, vasoconstrictors are occasionally added to close down blood vessels and delay absorption. Epinephrine (adrenaline) is usually used, at a dose of 1:200 000 (5 μg/mL) or 1:400 000 (2.5 μg/mL). Some procedures require local anesthetics without epinephrine and this should always be borne in mind when using local analgesic techniques.

Elimination of the drug is through the lungs and liver. Plasma cholinesterases break down the drugs belonging to the ester family, and drugs from the amide group are broken down by mixed function oxidases in the liver.

Toxicity

Toxic reactions with local anesthetic drugs are possible. The signs must be recognized and treatment should be prompt. The IV dose of lidocaine that will produce convulsions in dogs is 20.8 ± 4 mg/kg bodyweight (BW) (although a figure of 10 mg/kg BW is often quoted as being the toxic dose), and that of bupivacaine is 4.31 ± 0.36 mg/kg BW. The maximum dose of 2% lidocaine administered to the average, 4-kg cat should be 2 mL. A dose of IV bupivacaine of 1.2 mg/kg BW is sufficient to cause cardiovascular depression in cats. In small patients, it is advisable to decrease the concentration of local anesthetics in order to increase the volume.

Central nervous system toxicity

The signs of central nervous system toxicity usually manifest before cardiac signs, except with bupivacaine. The initial sign is drowsiness, which may be missed in sedated animal patients. Clinical signs degenerate to

tremors and grand mal seizures as toxicity progresses. Treatment of convulsions is by rectal or IV diazepam (0.2 to 0.4 mg/kg BW), IV phenobarbital (2 to 4 mg/kg BW, up to 20 mg/kg BW), or pentobarbital (5 mg/kg BW, up to 20 mg/kg BW). An airway should be provided, if necessary, and oxygen administered.

Cardiovascular toxicity

The effects of local anesthetics on the cardiovascular system are mediated through direct actions on the heart and vascular system, and interference with the autonomic nervous system. Local anesthetics decrease electrical excitability, conduction rate, and force of contraction, and cardiac arrhythmias are common. The intense depression of the cardiac conducting tissue produced by bupivacaine can be difficult to treat, if treatment is not prompt; whereas, lidocaine cardiodepression is not as difficult to treat. Treatment should be directed towards cardiovascular support, with fluids, oxygen, and inotropes.

Methemoglobinemia

Methemoglobinemia is formed when ferrous iron (Fe^{2+}) in hemoglobin is oxidized to the ferric form (Fe^{3+}). This form of hemoglobin is not capable of carrying oxygen or carbon dioxide; dogs can tolerate methemoglobin concentrations of less than 20% but will show signs of fatigue, weakness, dyspnea, and tachycardia at concentrations between 20% and 50%. Prilocaine, benzocaine, lidocaine, and procaine can cause methemoglobinemia. Treatment consists of oxygen therapy and IV methylene blue (1.5 mg/kg BW).

Tissue toxicity

The drugs can cause irritation, and skeletal muscle appears to be the most sensitive. The potent, long-lasting anesthetics with high lipid solubility appear to be more likely to cause tissue damage.

Allergic reactions

Although the number of occurrences is small, ester-linked local anesthetics are more likely to produce allergic reactions than are the amide-linked anesthetics, but preservatives, such as methylparaben, have also been implicated in some reactions.

Topical anesthesia

Eye

Local anesthetics can be applied topically to desensitize the cornea for performing minor procedures and examinations. Drugs used for this purpose are commercially prepared solutions of proparacaine 0.5%, tetracaine 0.5%, and butacaine 2%. The drugs rapidly desensitize the cornea, and the effects generally last for 10 to 15 min after one administration, but repeated doses can be added for anesthesia lasting 2 h without causing serious side effects. Some dogs and cats may better tolerate administration of the solution if it has been warmed prior to instillation.

Skin

Ethyl chloride spray can be used to provide short-term anesthesia of the skin. The spray is used for between 2 and 5 s and provides enough analgesia for taking skin biopsies or lancing abscesses. Limitations include the risk of frostbite, if large areas are frozen; short duration of effect (< 3 min); and the flammable nature of ethyl chloride.

A cream (EMLA cream; Astrazenica, Mississauga, Ontario) has been developed that contains a mixture of lidocaine and prilocaine with good penetration of the dermal layers. The area to be desensitized is covered with a clean dressing to prevent the patient from licking the cream. It is useful in nervous animals prior to IV or intra-arterial catheter placement.

Open wounds

Small mucosal wounds can be repaired after spraying with a local anesthetic spray (10% lidocaine). Anesthesia of the mucosal surface up to a depth of 2 mm is provided after approximately 1 to 2 min, and it lasts for about 15 min. Care should be taken not to overdose since one spray delivers 10 mg of lidocaine. Some preparations contain benzocaine and should be avoided, because of the risk of methemoglobinemia.

For small skin lacerations and skin incisions, a small amount of 0.25% bupivacaine instilled into the wound, left for 2 min, and then repeated once can provide effective analgesia.

Topical anesthesia provides good analgesia and is easy to administer. It is useful when administered alone or with sedation in order to provide patient comfort during minor examinations and/or surgical procedures. Part II will discuss methods for infiltration anesthesia and specific nerve blocks in order to provide regional analgesia/anesthesia for dogs and cats.

Bibliography

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