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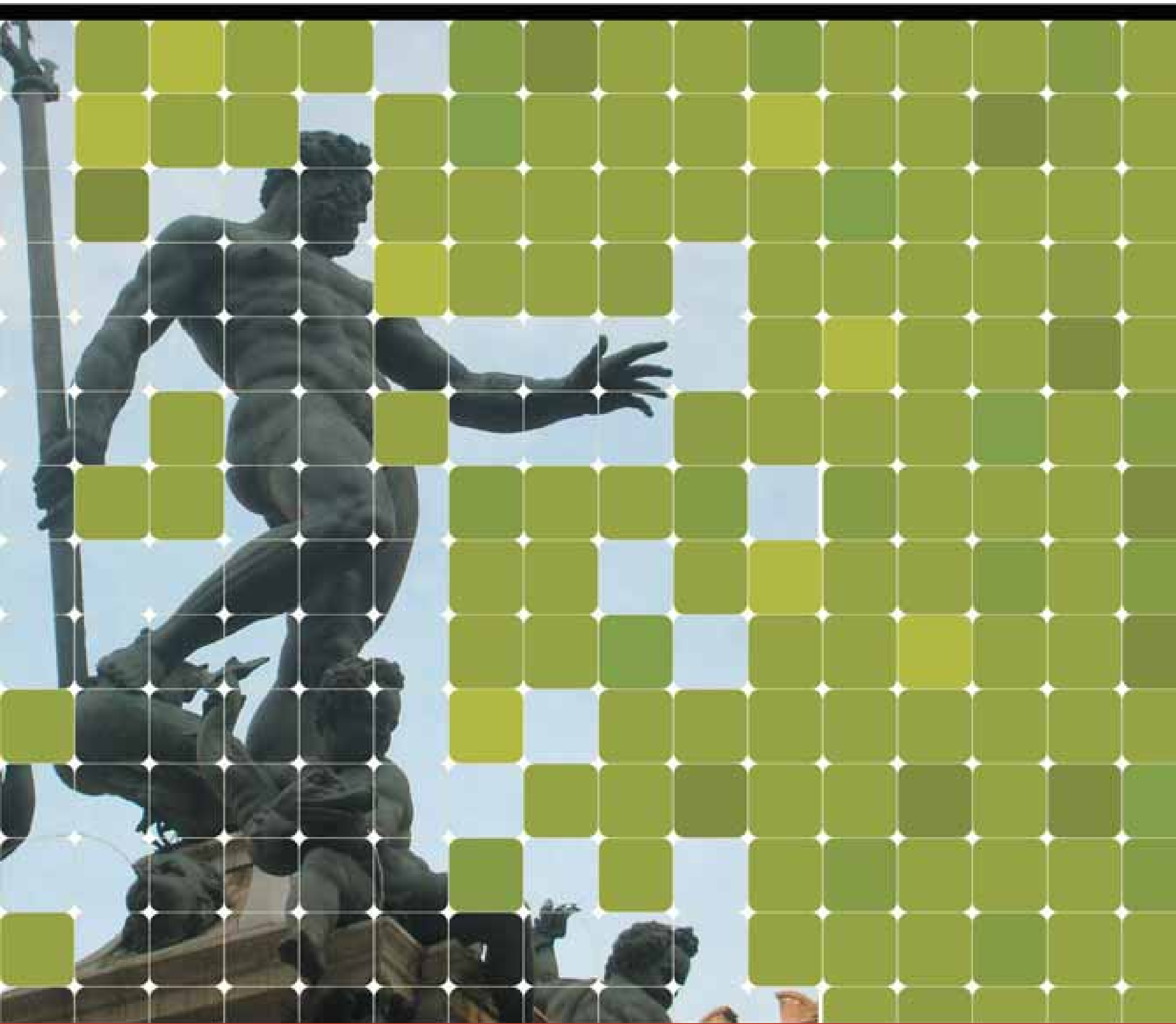

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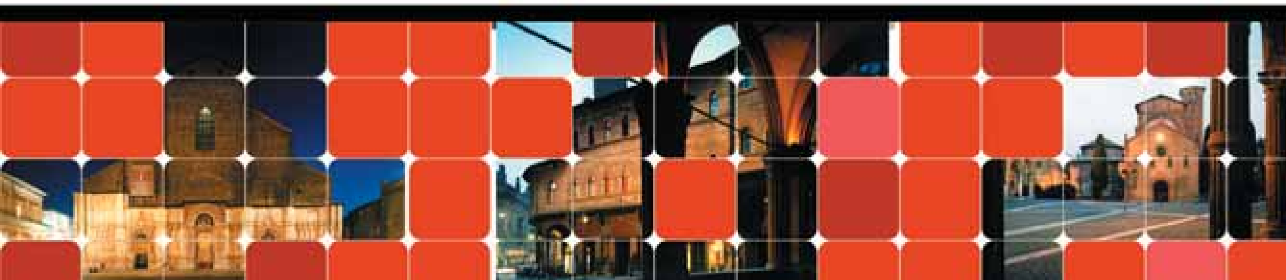

Forelimb blocks in orthopaedics: what is the evidence and what is new?

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In humans, several different techniques for brachial plexus blockade have been described, aiming to provide the best operating conditions for different types of surgery. Reported techniques are interscalene, supraclavicular, infraclavicular and axillary, including many variations aiming to improve the success rate and decrease the incidence of complications.

In general, complete anaesthesia of the arm except for the shoulder is best achieved with the infraclavicular block, while the interscalene block provides anaesthesia of the shoulder, but not always of the ulnar parts of the lower forearm and the hand. However, they rarely provide anaesthesia of caudal roots of the brachial plexus. With the axillary block anaesthetic gaps are expected in the region of the radial and muscolocutaneous nerves. In small animals, different anatomy has limited the application and/or modification of the techniques in common use in humans.

The success of a peripheral nerve block depends on how close to the appropriate nerve the local anaesthetic is placed. In humans, the administration of peripheral blocks has traditionally involved search for paraesthesia, which restricts the technique to awake and cooperative patient. The introduction into clinical practice of the nerve stimulator has offered a series of advantages during difficult blocks, teaching, and selective blocks with small amounts of local anaesthetics. In addition, the nerve stimulator facilitates the location of peripheral nerves in anaesthetized, deeply sedated and uncooperative patients, and reduces discomfort during nerve localization.

Recently, however, ultrasound-guided techniques are becoming increasingly popular as an aid or an alternative to electrolocation. Ultrasound guidance uses anatomic landmarks rather than a neurophysiologic endpoint (i.e. electroneurostimulation) to facilitate peripheral blocks, and it has been suggested that the combination of ultrasound guidance and electrolocation may offer the advantage of both the anatomical and electrophysiological confirmation of nerve identification and needle placement. Furthermore, some case series have demonstrated shortened procedure time and faster block onset compared with conventional techniques. Although not clearly demonstrated yet, potential benefits of ultrasound guidance include reduction in block-related complication and incidence of systemic local anaesthetic toxicity, and improvement in success rate and patient satisfaction.

In small animals regional anaesthesia is usually described as an adjunct rather than an alternative to general anaesthesia, providing a sparing effect on other anaesthetic agents and long term postoperative analgesia. In addition, peripheral nerve blocks are usually performed in an anaesthetized patient due to poor tolerance to proper positioning, needle insertion and advancement, and high current outputs (e.g. about 1mA) required by electrolocation. However, since its introduction the nerve stimulator has dramatically improved the success rate of many peripheral blocks in the dog and the cat, and has allowed for new blocks to be performed.

The recently introduced ultrasound guidance is promising in small animals as well. It may allow the veterinary anaesthetist to perform peripheral blocks with stimulated needles in an awake or slightly sedated cooperative patient, as the initial current output is much lower (i.e. 0.4mA) during a combined ultrasound-guided/ electrolocation technique than during standard electrolocation (i.e about 1mA). It should also be considered that electrical stimulation may become unnecessary with experience, although in people a motor response at or below 0.5 mA could only be elicited in 42% of successful blocks despite ultrasonographic evidence of close proximity to the targeted nerve.

Although different techniques for brachial plexus blockade have been described in small animals as well, very little scientific evidence is available. Brachial plexus block was first reported in 1951.[1] Since then blind injection of local anaesthetics into the axillary space at the level of the shoulder joint has been described and clinically used, although to date no clinical studies have investigated success rate, indications, contraindication, side effects and complications for this technique. According to unpublished data, however, some investigators have concluded that the onset time and quality of anaesthesia following a blind brachial plexus block are unpredictable.[2,3] It should also be noted that neither careful description of patient positioning, anatomical landmarks and surface markings used to locate the injection site has been made available, nor their influence on the success rate of a blind block assessed.

In 2000 Moens and Caulkett reported a 70% success rate in 10 research beagles receiving 0.78 ml kg^{-1} of 2% lidocaine through a feeding tube blindly placed in the axillary space for continuous brachial plexus blockade.[4] It was not until 2004 that peripheral nerve stimulator aided brachial plexus blockade was reported in small animals.[5]
Twelve research dogs undergoing surgery of the humerus were used. The insertion point was located using anatomical landmarks (i.e. axillary artery and costochondral junction of the first rib), and the anaesthetic solution (i.e. 1.1 ml kg^{-1} of 0.375% bupivacaine) was delivered in the axillary space using an insulated needle and a multiple stimulation technique. Although the authors claimed a 91.6% success rate, in actual fact success rate was 83.4% because two dogs did not underwent surgery and were withdrawn from the study due to block failure and severe hypotension respectively.
Using the same technique, Wenger *and others* enrolled 20 clinical dogs undergoing orthopaedic surgery of the forearm and carpus in a prospective, blind, placebo-controlled, randomized study.[6] They claimed a 100% success rate in dogs maintained with isoflurane (ET 1.3-1.4%) anaesthesia, and administered 0.25 ml kg^{-1} of a mixture of 2% lidocaine and 0.5% bupivacaine in the axillary space using a multiple stimulation technique. However, some dogs in the brachial plexus block responded to surgical stimulation despite 1 MAC isoflurane, and received intraoperative fentanyl. In addition, 1 dog required rescue analgesia (i.e. methadone) during the 8-hour postoperative monitoring period.
Anatomical landmarks to perform multiple stimulation technique at the axilla, and clinical use of commercially available set for continuous, nerve stimulator aided, brachial plexus blockade have been reported.[7,8] Furthermore, using the axillary approach and a single stimulation technique (i.e. flexion of the elbow) 0.3 ml kg^{-1} of solution was required to adequately stain the brachial plexus in a canine experimental model.[9] Recently, the use of ultrasound to approach the canine plexus in the axillary space has been reported in a prospective experimental trial.[10]
A posterior approach to the brachial plexus was introduced into clinical use in humans by Pippa in the 1990s.[11] It is a cervical paravertebral approach using the loss-of-resistance technique and a single injection of local anaesthetic, and has been shown to provide a wider area of analgesia compared to Winnie's lateral (i.e. interscalene) approach.[12] Although epidural spread is still possible, this approach has minimal chance to enter the neuraxis. A modified Pippa posterior approach (dorsal approach) to the brachial plexus has been successfully reported in a dog in 2006,[13] although first used by this author in 2001.
A lateral paravertebral approach to the canine brachial plexus has been described by Lemke.[3,14] Using the transverse process of the 6th cervical vertebra and 1st rib as anatomical landmarks, the ventral branches of C6, C7, C8 and T1 are individually blocked. The local anaesthetic is administered via a needle entering the lateral side of the neck and directed medially, and a multiple injection technique is used. Although the technique has been described twice, no clinical trial has reported its use. Unintended neuraxial (subarachnoid, subdural, epidural) anaesthesia is a potential complication of such a block, as well as unintentional spinal cord puncture through the intervertebral foramen, as already reported in humans for the interscalene and the Boezaart's modified posterior approach.
A similar approach, i.e. a craniolateral to caudomedial direction of the needle, using ultrasound-guided low-volume (i.e. 0.3 ml per site) vs high-volume (i.e. 1 ml per site) injections provided staining of all nerve routes in 11 canine cadavers.[15] However, staining of the epidural space and intervertebral foramen was noted in both low and high volume injections, and staining of the phrenic nerve in high-volume injections only. Such staining should be regarded as possible source of complications in a clinical setting, and might be related to the lateral approach, use of a standard needle, and targeting ultrasonographic landmarks rather than the individual nerve root.
As an alternative, Hofmaeister and Read described a dorsal approach in 9 canine cadavers using Lemke's anatomical landmarks, a multiple injection technique and a methylene blue solution.[16] At dissection, all individual nerves were successfully stained using 3 ml of staining solution in 3 out of 9 cadavers (33%), while C7 was stained in all cadavers. Indications, success rate and complications for this technique have never been investigated clinically.
The individual blockade of the radial, ulnar, musculocutaneous and median nerves (RUMM block) at the distal humerus has been suggested as an alternative to the axillary brachial plexus block, however no clinical reports of the technique have been published.
Recently, a RUMM block at the level of the midhumerus failed to provide complete simultaneous block of all nerves in all but one dogs,[17] although in people it provided a greater success rate than the traditional axillary approach.[18]
In conclusion, although regional anaesthesia may provide a sparing effect and long term postoperative analgesia during front limb surgery in dogs and cats, scientific evidence to support the use of a specific block for any specific procedure is currently lacking.

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