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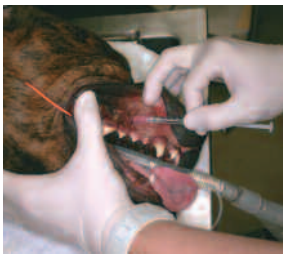
Pain Protocols for Common Elective Surgical Procedures



Providing adequate analgesia to patients undergoing elective surgery is more than just being humane or providing the type of care clients want and expect—proper pain management decreases morbidity and mortality and allows patients to recover more quickly.[1]

Pain Pathways

Understanding how pain is transmitted and perceived is necessary when designing an effective protocol to attenuate pain. In general, for a noxious stimulus to be perceived as painful, 4 steps must occur: The stimulus must be *transduced* into an afferent action potential. The action potential is then *transmitted* via an Aδ or C-fiber neuron to the dorsal horn of the spinal cord. From the dorsal horn of the spinal cord, the action potential is then carried to the thalamus and then to higher cortical centers. *Modulation* of the signal, either amplification or attenuation, can occur at any level. Finally, *perception* of the stimulus occurs when the signal reaches the higher brain centers and the patient "feels" the pain.

Analgesic Drugs

Local Anesthetics

Local anesthetics decrease neuronal conduction by inhibiting sodium influx and stopping propagation of the action potential. Local anesthetics can be administered epidurally, intrathecally, or perineurally. Most local anesthetics must be injected, but, anecdotally, prilocaine/lidocaine cream and lidocaine patches appear to be effective.

Nonsteroidal Antiinflammatory Drugs (NSAIDs)

NSAIDs have antiinflammatory, antipyretic, and analgesic properties. Some of the analgesia is due to central analgesic effects, but most comes from the drugs' ability to attenuate the inflammatory response. Most NSAIDs inhibit the cyclooxygenase (COX) enzymes, which catalyze the formation of prostaglandins and thromboxane.

COX occurs as the isoenzymes COX-1 and COX-2, which have varied effects in the body. The specificity for inhibiting COX-1 or COX-2 is dependent on the drug and the species. NSAIDs are contraindicated in hypovolemic or hypotensive patients, and should be used with caution in patients with renal or gastrointestinal disease.

Opioids

At least 3 opioid receptors have been identified: mu (μ), kappa (κ), and delta (δ). However, only the μ and κ receptors are routinely manipulated to provide analgesia. Opioid receptors are present in peripheral tissues, including the joint capsule,[2] dorsal horn of the spinal cord, and brain. Binding of the opioid agonists increases K^+ conductance, which causes hyperpolarization and decreases neurotransmitters, such as acetylcholine, substance P, dopamine, and norepinephrine. Side effects associated with opioids may include nausea, respiratory depression, and bradycardia.

Pure μ-opioid agonists commonly available are morphine, hydromorphone, oxymorphone, and fentanyl. Pure agonists have a dose-dependent effect. Buprenorphine, a partial μ agonist, has a ceiling effect (increased dosing above a certain level will not increase the effect).

Butorphanol is a κ-opioid agonist (with μ-opioid antagonist activity). In general, the currently available κ agonists provide less intense analgesia, but also cause fewer side effects.

Most opioids used in veterinary medicine are controlled drugs and are generally administered by injection because of poor oral bioavailability; however, fentanyl patches have become a popu-

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COX = cyclooxygenase; K^+ = ionized potassium; NSAID = nonsteroidal antiinflammatory drug

lar transdermal option. Since most μ opioids decrease the normal response to elevations in arterial carbon dioxide levels, they should be used cautiously in hypoxemic patients or those in respiratory distress.

Alpha-2 Agonists

Alpha-2 agonists (eg, medetomidine) produce sedation and analgesia by binding to presynaptic α-2 receptors at the locus ceruleus in the brain, dorsal horn of the spinal cord, and sympathetic nerve endings. Binding of these presynaptic receptors causes a decrease in norepinephrine release, which results in decreased pain conduction, decreased arousal, and increased parasympathetic (vagal) tone. Microdoses (eg, 0.5 to 2 μg/kg of medetomidine) of α-2 agonists are quite useful after surgery to provide sedation and analgesia and to treat anxiety and dysphoria.

Alpha-2 receptor agonists also bind postsynaptically to α receptors in the peripheral vasculature, causing intense vasoconstriction. The vasoconstriction can lead to a reflex bradycardia and reduction in cardiac output. They should be used with caution in dehydrated or hypovolemic patients or those with cardiovascular instability.

Atypical Opioid Agonist

Tramadol has a mild μ-opioid action, but its metabolite (M1) has 200 times the opioid binding affinity of the parent compound.[3] Additionally, some if not most, of tramadol's analgesic properties are due to inhibition of norepinephrine and serotonin (5HT) reuptake.

Tramadol should be used with caution in patients taking other serotonin reuptake inhibitors (eg, selegiline hydrochloride or fluoxetine) because the combination can lead to a potentially fatal serotonin syndrome.[4]

NMDA-Receptor Antagonists

Ketamine (injectable) and amantadine (oral) are NMDA (N-methyl-D-aspartic acid)-receptor antagonists. These drugs prevent or attenuate central sensitization (wind-up) at the dorsal horn of the spinal cord[5] and thus may also prevent neuropathic pain, such as postamputation wind-up and neuromas. Ketamine is given at subanesthetic doses; thus, behavioral side effects should not be seen.

Phenothiazines

Acepromazine is a phenothiazine, a major tranquilizer that works by antagonizing dopamine receptors (D2). When administered alone, acepromazine provides tranquilization only and no analgesia. However, when administered with an opioid agonist, acepromazine potentiates the analgesic duration of the opioid.[6]

The major side effect of acepromazine is a peripheral α-1 blockade that causes vasodilation. It is contraindicated in patients for which vasodilation is an unwanted side effect, such as those with cardiac insufficiency, hypovolemia, or hypotension.

Multimodal Analgesia

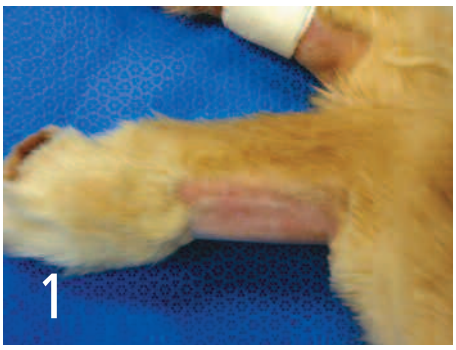
Pain information can be attenuated at differing sites along the pain pathway. The modulation of pain is synergistic when pain is treated by more than one pathway. The duration of effect is enhanced when multimodal analgesic techniques are used. An example of multimodal analgesia includes the use of NSAIDs with opioids or local blocks with an α-2 agonist.

Routes of Administration

The current convention is that analgesics should be given orally or injected into a vein or muscle. It is a paradigm shift to contemplate alternative routes of administration. However, such a shift has advanced the success of analgesia in humans and animals.

Transmucosal

Buprenorphine has good absorption when administered transmucosally (between the teeth and gums) to cats[7] and dogs.[8]



Fentanyl patch on shaved tarsus of a dog

Transdermal

Opioids and lidocaine are available in long-acting patches. The effect of transdermal opioids is systemic because therapeutic plasma levels are reached within a day of application in dogs and cats (**Figure 1**). Conversely, the effects of lidocaine patches are local because therapeutic plasma levels are not reached.[9]

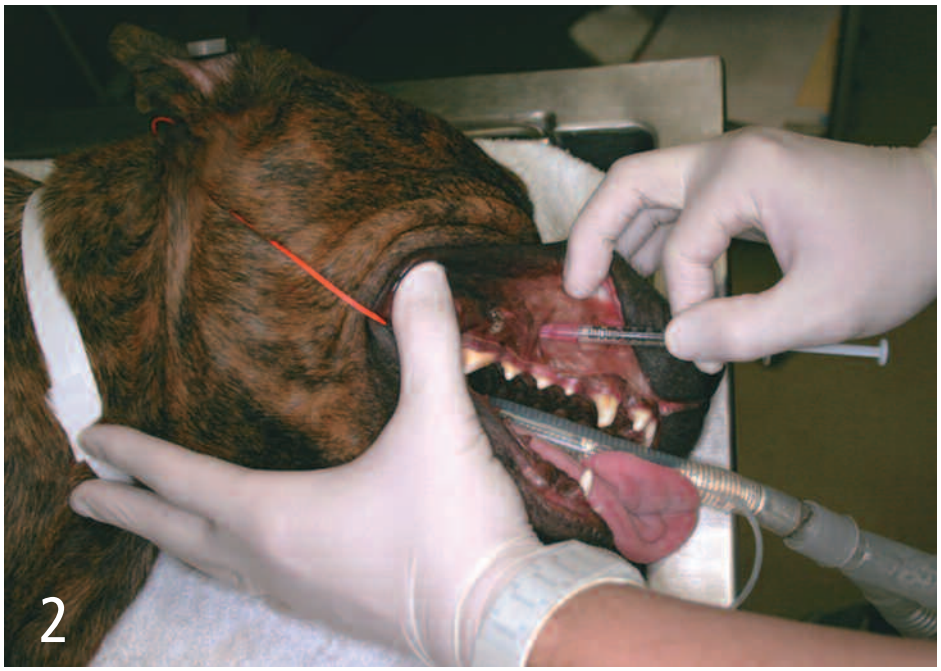
Perineural/Intraarticular

Local anesthetics injected perineurally can provide significant analgesia for soft tissue, bone, neurologic, and dental pain. Examples include line blocks for incisions, ring blocks for declawing, and dental blocks for tooth extractions (**Figure 2**). Joint capsules have a high density of opioid receptors,[2] which can be manipulated to provide local analgesia. Injections of opioids with or without local anesthetics can provide long-acting (> 12 hours) pain relief in the stifle joint.

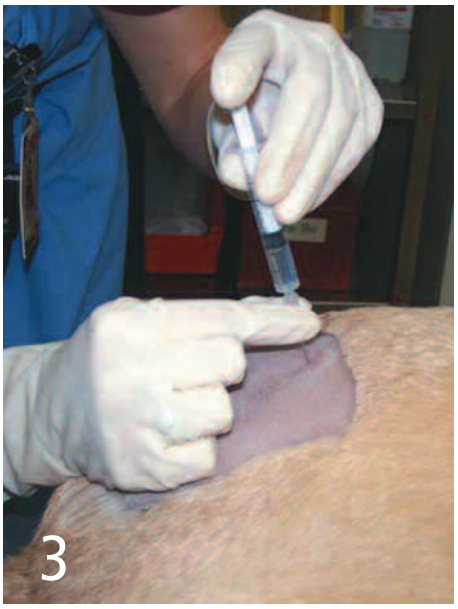
Constant Rate Infusions

Constant rate infusions of opioids, ketamine, α-2 agonists, and lidocaine can be administered to patients alone or in conjunction during and after anesthesia and surgery. The advantage of a constant rate infusion is that plasma levels fluctuate less; thus, the patient is more comfortable with smaller doses and probably will have fewer side effects. Constant rate infusion of lidocaine is not recommended in cats because of cardiodepressive effects.[10]

NMDA = N-methyl-D-aspartic acid; NSAID = nonsteroidal antiinflammatory drug



Infraorbital nerve block in a dog



Epidural administration of morphine and bupivacaine in a dog

Epidural/Spinal

The use of epidural or spinal analgesia for hindlimb orthopedic procedures is not unknown to most veterinarians. However, it takes some creative thinking to realize that epidural administration of opioids (eg, morphine) in larger volumes than used for hindlimb procedures can provide effective analgesia for thoracic surgery or forelimb amputations (**Figure 3**).[11,12]

Preemptive Analgesia

Although the extent of benefit is controversial, human and veterinary patients given preemptive analgesia have overall decreased pain scores, need less rescue analgesia, and need less overall pain medication.[13] Therefore, whenever possible, analgesic techniques should be used before a noxious stimulus is encountered.

At-Home Use

Although opioids are the mainstay of short-term pain therapy, most have poor bioavailability when administered orally. Until recently, veterinarians had few options for analgesia outside of the hospital setting.

- **Oral:** NSAIDs, amantadine, and tramadol are all effective orally.
- **Transmucosal:** Buprenorphine is effective when given transmucosally in dogs and cats
- **Transdermal:** Fentanyl patches and, anecdotally, lidocaine patches[14] have been deemed effective in both dogs and cats.

Analgesic Strategies*

Table 1 (page 17) shows commonly used analgesics with doses. **Table 2** (page 18) lists sample protocols.

Mild soft tissue trauma (eg, feline castration, mass removal):

- NSAID† plus opioid (μ or κ) with or without acepromazine
- At-home: NSAID†

Moderate soft tissue trauma (eg, ovariohysterectomy, mass removal, anal-gland excision):

- NSAID† plus opioid (μ) with or without acepromazine, epidural, or constant rate infusion (opioid, lidocaine, and/or ketamine)
- At-home: NSAID† with or without buprenorphine or tramadol

Severe soft tissue trauma (eg, thoracotomy, amputation, ear canal ablation):

- NSAID† plus opioid (μ), epidural/local block, constant rate infusion (opioid, lidocaine, and/or ketamine), with or without fentanyl patch or lidocaine patch
- At-home: NSAID† plus fentanyl patch or buprenorphine or tramadol

Moderate orthopedic pain (eg, cruciate ligament repair):

- NSAID† plus opioid (μ) with or without acepromazine, epidural/joint block, constant rate infusion (opioid, lidocaine, and/or ketamine)
- At-home: NSAID† plus fentanyl patch

Severe orthopedic pain (eg, bone fracture, declawing):

- NSAID† plus opioid (μ) with or without acepromazine, plus epidural/local block plus

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* Appropriateness of protocols must be assessed for each patient individually.
† NSAIDs should be used only when appropriate (see contraindications mentioned earlier in article).

Table 1. Commonly Used Analgesics

Drug	Dog	Cat
Single dose		
Buprenorphine	0.01–0.02 mg/kg SC, IM, IV	0.01–0.02 mg/kg SC, IM, IV
Butorphanol	0.2–0.4 mg/kg SC, IM, IV	0.2–0.4 mg/kg SC, IM, IV
Carprofen	4.4 mg/kg SC (Q 24 H)	2–4 mg/kg SC (once)*
Dexmedetomidine	0.5–10 µg/kg IM, IV	0.5–10 µg/kg IM, IV
Hydromorphone	0.05–0.2 mg/kg SC, IM, IV	0.05–0.2 mg/kg SC, IM, IV
Medetomidine	1–20 µg/kg IM, IV	1–20 µg/kg IM, IV
Meloxicam	0.2 mg/kg SC, IV	0.1–0.3 mg/kg SC, 0.5 mg/kg PO§
Morphine	0.1–1.0 mg/kg SC, IM, IV	0.1–1.0 mg/kg SC, IM, IV
Constant rate infusion		
Fentanyl	0.1–0.7 µg/kg/min	0.1–0.7 µg/kg/min
Ketamine	2–20 µg/kg/min	2–20 µg/kg/min
Lidocaine	10–50 µg/kg/min	Not recommended
Medetomidine	1–3 µg/kg/H	1–3 µg/kg/H
Morphine	2–6 µg/kg/min	2–4 µg/kg/min
Intraarticular (stifle)		
Morphine (PFM) + bupivacaine	0.1 mg/kg PFM + 0.5 mg/kg bupivacaine	0.1 mg/kg morphine + 0.5 mg/kg bupivacaine
Epidural (pelvis & caudal)†		
Morphine (PFM) + bupivacaine	0.1 mg/kg PFM + 0.5 mg/kg bupivacaine	0.1 mg/kg PFM + 0.5 mg/kg bupivacaine
Epidural (abdomen & thorax)‡		
Morphine (PFM) + saline	0.1 mg/kg PFM + 0.2 ml/kg saline	0.1 mg/kg PFM + 0.2 ml/kg saline
Transdermal		
Fentanyl patch	1–2 µg/kg/H	1–2 µg/kg/H
Lidocaine patch	≤ 2 (5%) patches/20 kg	≤ 1 (5%) patch/cat
Transmucosal (between teeth & gum)		
Buprenorphine	0.01–0.02 mg/kg	0.01–0.02 mg/kg
Oral		
Tramadol	1–5 mg/kg PO	1–3 mg/kg PO

PFM = preservative-free morphine
* Carprofen is not approved for cats in the United States but is approved in the United Kingdom.
§ Oral dose of meloxicam is off-label.
† Total volume for epidural should not exceed 0.2 ml/kg.
‡ Total volume for epidural should not exceed 0.3 ml/kg.

constant rate infusion (opioid, lidocaine, and/or ketamine)
- At-home: NSAID† plus fentanyl patch with or without lidocaine patch

tables continue

NSAID = nonsteroidal antiinflammatory drug
† NSAIDs should be used only when appropriate (see contraindications mentioned earlier in article).

Table 2. Sample Analgesia Protocols

	Preemptive	Intraoperative	Postoperative	At-Home
Dogs				
Mild pain (eg, eyelid mass resection)	**Carprofen:*** 4.4 mg/kg SC **Buprenorphine:** 0.02 mg/kg IM			**Carprofen:*** 2 mg/kg PO Q 12 H for 2 days ***or*** 4.4 mg/kg PO Q 24 H for 2 days
Moderate pain (eg, OHE)	**Carprofen:*** 4.4 mg/kg SC **Hydromorphone:** 0.1 mg/kg IM	**Lidocaine:** Line block	**Hydromorphone:** 0.1 mg/kg IM	**Carprofen:*** 2 mg/kg PO Q 12 H for 2 days w/ or w/o **tramadol** or **fentanyl** patch ***or*** 4.4 mg/kg PO Q 24 H for 2 days w/ or w/o **fentanyl** patch
Severe pain (eg, forelimb amputation)	**Carprofen:*** 4.4 mg/kg SC **Hydromorphone:** 0.1 mg/kg IM **Morphine + saline:** Brachial plexus block epidural	**CRI ketamine:** 10 µg/kg/min **CRI fentanyl:** 0.3 µg/kg/min	**CRI ketamine:** 10 µg/kg/min **CRI fentanyl:** 0.3 µg/kg/min w/ or w/o **CRI medetomidine** (1 µg/kg/H) **Lidocaine** patch around incision	**Carprofen:*** 2 mg/kg PO Q 12 H for 3 days ***or*** 4.4 mg/kg PO Q 24 H for 3 days **Fentanyl** patch **Lidocaine** patch around incision
Cats				
Mild pain (eg, castration)	**Meloxicam:*** 0.2 mg/kg SC **Buprenorphine:** 0.02 mg/kg IM			**Meloxicam:*** 0.05 mg/kg PO Q 24 H†
Moderate pain (eg, splenectomy)	**Meloxicam:*** 0.2 mg/kg SC **Hydromorphone:** 0.1 mg/kg IM	**Lidocaine:** Line block	**Hydromorphone:** 0.1 mg/kg IM	**Buprenorphine:** ~~0.2~~ mg/kg transmucosally Q 12 H for 3 days w/ **meloxicam** (0.05 mg/kg PO*† for 3 days)
Severe pain (eg, bulla osteotomy)	**Meloxicam:*** 0.2 mg/kg SC **Hydromorphone:** 0.1 mg/kg IM	**CRI ketamine:** 10 µg/kg/min **CRI fentanyl:** 0.3 µg/kg/min	**CRI fentanyl:** 0.3 µg/kg/min w/ or w/o **CRI medetomidine** (1 µg/kg/H) **Lidocaine** patch around incision	**Buprenorphine:** ~~0.2~~ mg/kg transmucosally Q 12 H for 3 days w/ or w/o **meloxicam***

0.02

CRI = constant rate infusion; NSAID = nonsteroidal antiinflammatory drug; OHE = ovariohysterectomy
* NSAIDs only when appropriate for the patient
† Dose is off-label and should be used with caution.

See Aids & Resources, back page, for references, contacts, and appendices.

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