Feline Fibrosarcoma: Perioperative Management

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ABSTRACT: Aggressive and complete surgical excision is the treatment of choice for fibrosarcomas in cats. Thorough preoperative planning and meticulous surgical technique are necessary for optimal cosmetic, functional, and oncologic outcome. Perioperative pain management with an emphasis on preemptive analgesia and multimodal analgesia is essential to minimize patient morbidity.

Feline fibrosarcoma (FSA) is one of the most common subcutaneous neoplasms in cats. Typically, it is a locally aggressive tumor with a moderate metastatic rate of up to 22.5%1-7 and recurrence rates as high as 67%.1 Aggressive surgical excision is the treatment of choice.1,6-8

Techniques for surgical management of FSA have been reported in the literature, particularly in the past two decades with the emergence of vaccine-associated sarcomas. Wide, complete, en bloc surgical excision combined with adjuvant chemotherapy and preoperative radiation therapy has dramatically improved median disease-free intervals in cats with FSA.1,2,5,6,8,9 Despite the advances in improving long-term postsurgical outcome, there has been little discussion of the effects of various aspects of perioperative support on early postoperative outcome in cats undergoing extensive reconstructive surgeries. This article presents and discusses current techniques in the perioperative management of feline FSA.

PREOPERATIVE CONSIDERATIONS

Patient Assessment

A complete physical examination, complete blood count, serum chemistry panel, and urinalysis are completed before extensive reconstructive surgery. Some cats receiving preoperative radiation therapy may be anemic, which does not delay surgery but may necessitate planning for a transfusion. Cats often lose weight due to the stress of preoperative adjunctive therapy or the presence of the tumor. Occasionally, a feeding tube has already been placed to treat cachexia associated with radiation therapy. In all cases, plans for the provision of adequate nutrition after surgery are discussed with the owner and

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*Dr. Hardie discloses that she has received financial support from Nutramax Laboratories, Inc., Pfizer, and Schering-Plough.
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time limits are established for the placement of a feeding tube if the cat does not eat.10

The surgical site should be examined with great care. The extent of gross tumor and any change in tumor appearance or extent since the previous examination should be noted. If the tumor has changed, reimaging of the mass before surgery may be indicated. The extent of surgical resection required should be carefully marked out on the cat by using a permanent marker while the cat is conscious and sedated or anesthetized. Particular attention should be paid to the normal anatomic relationship between structures because this can be readily altered in cats by positioning. Cat skin is very mobile, and when the patient is anesthetized, the muscular tone in the cutaneous trunci is absent, potentially creating an inaccurate representation of which soft tissues overlie the mass and should be resected. Repeated evaluation allows optimal decision making regarding the extent of resection required.

Imaging

Because the pulmonary parenchyma is the most common site of FSA metastasis, three-view thoracic radiographs should be obtained before surgery or preoperative radiation therapy.1,4,7,8 Metastatic disease significantly reduces survival, and surgery is generally not recommended if metastasis is present.5 However, surgery may be indicated in a patient with metastatic disease to palliate pain from or infection of the primary mass if it is significantly compromising the patient’s quality of life. In these cases, the intent is to improve quality of life while accepting a truncated survival time.

Contrast-enhanced computed tomography (CT) may provide additional information for surgical planning. CT is especially useful in helping characterize tumor size and investigating the possibility of bony invasion (Figure 1). A CT image may also be needed for preoperative radiation planning. Magnetic resonance imaging (MRI) may aid in further characterization of FSAs. MRI is especially useful for investigating the soft tissues surrounding the tumor. It is used frequently in human medicine for preoperative planning and margin evaluation of some tumors.11,12 In a canine study comparing radiologic assessment of margins of appendicular osteosarcoma with histologic findings, MRI was more accurate than CT and orthogonal radiographs in estimating tumor margins.13 To our knowledge, a similar study has not been done in cats with FSA. However, cost and availability may limit the usefulness of MRI.

Surgical Considerations

Presurgical Planning

Aggressive and complete surgical excision is the treatment of choice for cats with FSA.3,4,6-8 Complete excision has been shown to improve survival and decrease the tumor recurrence rate.6-8 If the tumor is large or invading vital structures, surgical excision can be challenging. Before anesthesia, the desired surgical margins should be decided, and it should be determined whether the tumor can be resected while adhering to these margins. We recommend drawing an outline of the required resection on the animal during the assessment process. This also allows owners to be fully aware of the extent of resection. Physical manipulation of the mass and
advanced imaging may be required to more accurately estimate the gross tumor volume and determine proximity to vital and bony structures. Once the patient has been anesthetized and clipped, further palpation should be performed to reassess tumor size, position, and involvement with surrounding structures, and the extent of resection required should again be drawn directly on the cat. This allows a more accurate assessment of the extent of surgical resection and the techniques that will be required for reconstruction.

**Resection Principles**

Outlining the mass and the planned line of resection with a sterile surgical marker before incision is advised to ensure that the desired predetermined margins are adhered to during dissection. Ulcerated masses should be covered before excision to minimize contamination of the clean tissue bed. When excising an FSA, 3- to 4-cm margins are marked radially from the outlined edge of the gross tumor (Figure 2). Surgical instruments should not penetrate the primary tumor or breach the previously drawn margins. Intraoperative, iatrogenic seeding of soft tissue sarcomas by tumor-contaminated instruments has been reported in humans. The deep margin must extend at least one (preferably two) intact fascial plane(s) below the tumor. As dissection continues, retraction of the skin and other tissues can make it difficult to determine the appropriate radial point of resection (Figure 3). Thus, once the deep margin has been established and before full excision of the mass, placing tacking sutures to connect the deep margin to the skin has been recommended to maintain orientation (Figure 4). This also helps to orient the resected specimen before histopathologic evaluation, making the determination of resection margins more meaningful. Inking of the deep margins permits further determination of microscopic margins (Figure 5). Care should be taken to minimize the use of cautery at surgical margins because it can cause tissue artifact and necrosis, making it difficult to evaluate the margins for the presence of neoplastic cells. Electrocautery has also been shown to significantly reduce the tensile strength of fascial incisions in rats. This may become clinically significant in tissue that has already been irradiated.
gesic catheter can be used concurrently with an active drain if the suction on the drain is released for 60 to 90 minutes following instillation of a local anesthetic (e.g., bupivacaine) into the wound. Bandaging of the surgical incision is unnecessary.

**Area-Specific Resection and Reconstruction**

**Interscapular Masses**

The interscapular region and the dorsal cervicothoracic spine are the most common locations for vaccine-associated sarcomas.\(^1,7,8\) Resection of large amounts of tissue in these areas can often result in considerable dead space. Removal of the dorsal spinous processes and/or a partial scapulectomy may be needed to ensure appropriate deep and lateral margins.

With large and midline masses, excision can result in removing all muscular support from the proximal scapulae. In our experience, this can result in significant loss of forelimb function and poor cosmesis as the proximal scapulae displace dorsally and laterally during weight bearing. In a naturally sitting cat, the scapula is rotated caudoventrally.\(^19\) The opposing muscular force most likely comes from the occipitotransversus muscle and other craniodorsal muscles such as the rhomboideus.\(^19\) Excision of these muscles is likely with removal of a dorsal interscapular FSA or with partial scapular excision, resulting in possible destabilization of the normal

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Figure 4. The deep margin of the mass has been sutured to the skin before full excision. Multiple long suture ends on the dorsal edge (white arrow) of the mass and a single short suture end (black arrow) on the cranial edge of the mass help orient the tissue after it has been removed.

Figure 5. Inking the deep margin of the mass.
can result in dramatically reduced limb function when combined with the extensive resection of other interscapular tissues that is usually required. Muscle attachments and innervation to the distal scapula and forelimb should be maintained. Again, securing the remnant scapula to the body wall or dorsal spinous processes should be attempted to improve functional outcome. In the one veterinary study published on partial scapulectomies, a cat had excellent postsurgical function but did have a local recurrence.\textsuperscript{20} One case report describes excision of a recurrent vaccine-associated sarcoma and the underlying scapular spine. The scapula was reconstructed using a latissimus dorsi muscle flap anchored to the scapula through bone tunnels. Postoperative function was excellent and healing was uneventful, but the tumor recurred 160 days postoperatively.\textsuperscript{21}

Although excision of an interscapular tumor creates a large skin defect, the skin is fairly mobile in this region. The defect can be closed in an “H” or “Y” pattern to minimize tension at skin edges (Figure 8).

**Proximal Forelimb Masses**

Proximal forelimb FSAs are a unique surgical challenge. Although their primary location may be on the
The surgical margin may extend to the neck, interscapular region, or thorax. Partial scapulectomy, forelimb amputation, or amputation with resection of body wall may be required for full excision. In our experience, it is better to perform an amputation that includes the scapula than to attempt to save the limb, risking inadequate resection and poor wound healing due to excessive mobility of the remaining scapula.

### Flank and Lateral Thoracic Masses

The limiting factor for excision of flank and thoracic masses is the depth to which the tumor extends. These masses can invade the deepest aspects of the body wall. In such cases, full-depth body wall resection may be required to achieve clean margins. Aggressive lateral excision is recommended with removal of ribs as indicated to achieve 3-cm margins. Such resections can result in significant tissue defects (Figure 9). The principles of oncologic surgery suggest minimizing foreign implants, such as mesh, and avoiding extensive reconstruction of the area using pedicle flaps when it is possible that the tumor may not be completely resected. This is certainly the case in most feline FSA resections. However, the wounds created from feline FSA resections are sometimes so great that advanced reconstructive techniques are required to adequately close them.

After caudal thoracic rib resection, the diaphragm can be advanced cranially and apposed to the intercostal muscles or anchored to ribs to close the thoracic cavity without the need for synthetic mesh. To close large flank wounds, muscle layers should be initially apposed with absorbable suture in a simple interrupted or mattress pattern. Closure then proceeds superficially. There should be no tension on the skin closure because excessive tension leads to dehiscence.

Synthetic mesh has been used to reconstruct body walls in cats. Synthetic mesh comes in a variety of compositions, but the most common mesh used in veterinary medicine is a monofilament polypropylene mesh. The mesh should be approximated to the wound with 1 cm of overlap around the periphery of the defect. The edge is then folded over to improve the holding strength of the mesh and prevent the relatively sharp edges of the mesh from making contact with the underlying lung or other organs. Alternatively, the mesh may be folded in half to uniformly double the thickness present at the defect. The mesh is then sutured either to adjacent ribs along the intrapleural surface of the thoracic cavity or to the deep fascia of the abdominal wall defect in a simple interrupted or mattress pattern (Figure 10). Muscle layers are then apposed, and the defect is routinely closed. Meticulous tacking down of tissue planes to the mesh and underlying tissues decreases dead space and may minimize postoperative complications, which have been reported at a rate of 50%. Axial pattern flaps can also be used to close large defects. Lidbetter and colleagues described performing a

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**Figure 8.** Skin closure in a “Y” pattern after FSA excision. Cranial is to the left in both images; in the second image, ventral is toward the top of the image. A wound catheter has been placed in each patient.
radical body wall resection and closing the wound with polypropylene mesh combined with a caudal superficial epigastric flap in six cats. At 17.5 months (525 days), there was no local recurrence in any cat.

**Proximal Hindlimb Masses**

Hemipelvectomy is indicated for cats with masses on the lateral aspect of the pelvis that do not cross the midline and for cats with proximal hindlimb masses that extend into the soft tissues associated with the pelvic bones. Hemipelvectomy involves removing the adjacent hindlimb and part or all of the ipsilateral pelvic bones. There is one report of a hemipelvectomy in a cat, and this cat did not experience recurrence at 37 months.24

**Distal Forelimb and Hindlimb Masses**

Because 3-cm margins are the minimal excision requirements, distal limb FSAs are typically treated with amputation. Because a clean margin can be more easily achieved with amputation, these cats tend to live longer and have a lower recurrence rate.34 This is the reasoning behind the current recommendation to vaccinate cats at distal limb sites.

**POSTSURGICAL CONSIDERATIONS**

**Pain Control**

Perioperative pain control is of paramount importance in cats undergoing extensive reconstructive surgery.25,26 Unlike straightforward excision of small masses, many of these surgeries involve removing bone, resecting an extensive amount of muscle, severing large nerves, and performing reconstructions involving significant tension on tissue. Managing pain in these patients is often challenging, and a preemptive, multimodal approach is indicated to achieve adequate pain control. *Preemptive* refers to the use of analgesics before surgery to attempt to block or minimize the establishment of central sensitization.27–29 For example, we routinely administer epidural injections to these cats before surgery to decrease inhalant anesthetic requirements and improve postoperative recovery through decreased pain.30,31 *Multimodal* refers to the concurrent use of multiple classes, or types, of analgesics, often using various routes of administration. As more has become known about pain transmission over the past few years, it has become obvious that pain transmission involves a variety of pathways and multiple mechanisms and transmitter systems. It is therefore unlikely that a single class of analgesics, regardless of dose, will provide complete analgesia. This is confirmed by clinical experience. The combination of two or more classes of analgesics is much more effective. The effect from these drugs is often additive, and smaller doses of the individual drugs can be used, thus decreasing the likelihood of adverse effects from any one drug. In these complex surgical cases, we usually use three to four classes of drugs to provide maximal perioperative pain relief with minimal individual doses of each drug (Table 1).

Ideally, adequate preoperative and intraoperative multimodal analgesia (e.g., epidural administration, intraop-
ervative narcotics, nerve blocks) should minimize the postoperative pain experienced by these patients. The goal of postoperative analgesia is then to continue providing maximal pain relief with minimal morbidity. The provision of effective pain relief to cats undergoing major surgery is difficult due to the difficulties of assessing pain in cats, the absence of approved drugs for use in cats, and the absence of studies evaluating pain relief after major surgery in cats.

Our patients are evaluated for pain at least every 4 hours. A major part of the evaluation process is palpation of the wound and the surrounding area. Thresholds to mechanical stimulation at the site of surgery are altered after surgery in clinical cases. This can be readily appreciated by palpation. If an aversive response is seen, the analgesic regimen (doses, drug types, and routes of administration) is reevaluated.

The following discussion of the use of the major classes of analgesics in cats is based on clinical experience. These recommendations may change as more research in this relatively new area of veterinary medicine is conducted and more is learned about the clinical toxicity of these drugs.

**Opioids**

Epidural analgesics administered before surgery may decrease inhalant anesthetic requirements and ease postoperative recovery. An epidural injection before surgery is especially effective in patients with hindlimb amputations. Epidural opioids combined with a local anesthetic have been shown to provide superior analgesia compared with an opioid alone for surgery in the caudal half of the body. Opioids alone are used for epidurals in cats undergoing resections in the cranial half of the body.

At our institution, an intravenous bolus dose of an opioid (typically hydromorphone) is given at extubation. The patient is then transferred to a constant-rate infusion (CRI) of an opioid for 24 to 48 hours after surgery to maximize comfort and provide some sedation. We generally use fentanyl for the CRI because fentanyl serum concentrations can be reliably altered within 20 minutes of changing the CRI delivery. We also use hydromorphone as a CRI. If additional analgesia is needed, a bolus dose of the narcotic given as a CRI can be administered as needed. If this need recurs frequently, increasing the dose of drug administered as a CRI may be indicated for better analgesic control. Hyperthermia occasionally occurs in cats receiving fentanyl, hydromorphone, and other opioids. Although rare, hyperthermia must be considered in a postoperative patient that is becoming restless and agitated. Hyperthermia resolves when the opioid is discontinued.

A fentanyl patch can be placed before or immediately after surgery. If placed after surgery, injectable opioids should be given until the patch is likely to be effective (6 to 12 hours in cats). Weaning cats from CRIs or changing to bolus administration should begin once the patch has reached maximal effect. In our experience, in the immediate postoperative period (12 to 24 hours), a fentanyl patch alone typically does not provide reliably adequate analgesia for cats with extensive resections.

Buprenorphine is a partial µ-agonist that has recently received attention in the literature for its ability to provide analgesia in cats via injectable and transmucosal administration. Although it is a partial µ-agonist, some studies have reported superior analgesia compared with pure µ-agonists in cats. The longer duration of action makes this medication more suitable for bolus administration.

Hydromorphone and oxymorphone are pure µ-agonists. They have been used for bolus administration but have a shorter duration of action than buprenorphine and can induce pyrexia in cats (as fentanyl can), particularly at the higher doses needed to maintain adequate pain control after FSA resection. Butorphanol is a mixed agonist–antagonist. One study in cats demonstrated decreased analgesia compared with and when combined (text continues on page 728)
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<tr>
<th>Drug</th>
<th>Feline Dose</th>
<th>Notes</th>
<th>References</th>
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<tr>
<td>Acetaminophen (paracetamol)</td>
<td>Contraindicated</td>
<td>Small doses can rapidly cause death in cats.</td>
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<tr>
<td>Aspirin</td>
<td>10 mg/kg PO q48h</td>
<td>Can readily cause gastrointestinal ulceration.</td>
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<tr>
<td>Bupivacaine</td>
<td>1–2 mg/kg for individual nerve block. Suggested no more than 4 mg/kg/day.</td>
<td>Can be used preoperatively, intraoperatively, or at the end of surgery. Can be instilled into the wound via wound catheters postoperatively (1 mg/kg at time 0, followed by 0.5 mg/kg at 6 hr, 12 hr, 18 hr, and 24 hr). 0.5 mg/kg has been shown to have no cardiac effects in cats, but information on repeated dosing of cats with bupivacaine does not exist.</td>
<td>Nishikawa et al&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>Buprenorphine</td>
<td>20 µg/kg IM or IV or sublingual q8–12h</td>
<td>In an experimental study, noncompounded injectable liquid buprenorphine provided good antinociception when administered sublingually (20 µg/kg) for 6 hr. This formulation is not resented by cats. IV buprenorphine provides analgesia for the same period when administered at the same dose. The sublingual route is well tolerated by cats and may provide a good way to provide postoperative analgesia at home. Clinical experience suggests that a smaller dose (5–10 µg/kg) may be more appropriate for administration over several days but may still result in anorexia after 2–3 days. We recommend bid or q12h dosing for at-home use.</td>
<td>Lascelles et al&lt;sup&gt;c&lt;/sup&gt;, Robertson et al&lt;sup&gt;f&lt;/sup&gt;</td>
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<tr>
<td>Butorphanol&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.1–0.4 mg/kg IV or IM q1–2h</td>
<td>Relatively poor and unpredictable analgesic in cats; good sedation; short duration of action; duration of sedation outlasts the duration of analgesia; no obvious dose-response relationship.</td>
<td>Sawyer and Rech&lt;sup&gt;f&lt;/sup&gt;, Lascelles and Robertson&lt;sup&gt;b,l&lt;/sup&gt;</td>
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<tr>
<td>Butorphanol (oral)</td>
<td>0.2–1.0 mg/kg PO q6h</td>
<td>One study suggested that the provision of oral butorphanol after surgery may be beneficial.</td>
<td>Carroll et al&lt;sup&gt;j&lt;/sup&gt;</td>
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<td>Carprofen&lt;sup&gt;j&lt;/sup&gt;</td>
<td>1–2 mg/kg SC or IV single dose</td>
<td>Can safely be given preoperatively in healthy animals; is approved in the United Kingdom and other countries at 4 mg/kg as a single perioperative dose; lower doses (1–2 mg/kg) appear to be as effective as higher doses (4 mg/kg) and give an extra margin of safety.</td>
<td>Balmer et al&lt;sup&gt;k&lt;/sup&gt;, Lascelles et al&lt;sup&gt;i&lt;/sup&gt;, Slingsby and Waterman-Pearson&lt;sup&gt;p&lt;/sup&gt;</td>
</tr>
<tr>
<td>Carprofen (oral)</td>
<td>Not enough data to make recommendations about multiple dosing</td>
<td>Has a long and unpredictable half-life in cats, making it impossible to predict how it will be tolerated in an individual cat.</td>
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<tr>
<td>Deracoxib</td>
<td>Not recommended (no data)</td>
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<tr>
<td>Etodolac</td>
<td>Not recommended (no data)</td>
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<tr>
<td>Fentanyl (transdermal patch)</td>
<td>2–5 µg/kg/hr</td>
<td>Cats weighing 8.8–17.6 lb (4–8 kg) can use a 25 µg/hr patch. In cats weighing &lt;8.8 lb (&lt;4 kg), half of the patch can be left covered, but delivery is unpredictable. Patches should not be cut. The decay in plasma levels following patch removal is slow, and it is likely that in some cats, efficacy can last up to 6 days from one patch.</td>
<td>Franks et al&lt;sup&gt;n&lt;/sup&gt;, Glerum et al&lt;sup&gt;s&lt;/sup&gt;, Davidson et al&lt;sup&gt;s&lt;/sup&gt;</td>
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### Table 1. Recommendations for Postoperative Analgesic Use in Cats

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<tr>
<th>Drug</th>
<th>Feline Dose</th>
<th>Notes</th>
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<tr>
<td>Flunixin meglumine</td>
<td>1.0 mg/kg SC single dose</td>
<td>Daily dosing for 7 days results in increased rate of metabolism of the drug, but liver enzyme concentrations also rise, suggesting that liver toxicity may be a problem with prolonged dosing.</td>
<td>Taylor et al&lt;sup&gt;7&lt;/sup&gt;</td>
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<td></td>
<td>0.5–1.0 mg/kg PO q24h for 7 days</td>
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<tr>
<td>Hydromorphone</td>
<td>0.02–0.1 mg/kg IM or IV q6–8h</td>
<td>For CRI, start at 0.02 mg/kg/hr for a few hours, and then decrease to 0.01 mg/kg/hr for the next 12 hr postoperatively, CRI seems effective. Hyperthermia has been seen following administration.</td>
<td>Lascelles and Robertson&lt;sup&gt;4&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>0.01–0.03 mg/kg/hr CRI</td>
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<tr>
<td>Ketamine&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1–1.0 mg/kg</td>
<td>Small doses are thought to provide analgesia, especially in cases of chronic or long-standing pain, by virtue of NMDA antagonism. In dogs, CRI rates of 10 µg/kg/min intraoperatively and 2 µg/kg/min postoperatively were found to improve pain control.&lt;sup&gt;7&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>2–5 µg/kg/min CRI</td>
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<tr>
<td>Ketoprofen&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1 mg/kg SC q24h, maximum of 3 days</td>
<td>The injectable form has been compounded in palatable form by one author (BDXL) and appears to be effective.</td>
<td>Slingsby and Waterman-Pearson&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ketoprofen (oral)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1 mg/kg PO q24h, maximum of 5 days</td>
<td>The tablets have been compounded in palatable form by one author (BDXL) and appear to be effective.</td>
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<tr>
<td>Lido/ lignocaine&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1–4 mg/kg for individual nerve blocks or regional infiltration</td>
<td>Can be used preoperatively, intraoperatively, or at the end of surgery. Can be instilled into the wound via wound catheters postoperatively. <strong>Do not use as a CRI</strong>; cardiotoxicity is readily seen.</td>
<td>Pypendop and Ilkiw&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Medetomidine&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1–5 µg/kg IV as needed</td>
<td>When combined with other sedative agents, this drug can cause significant cardiopulmonary changes. The provision of small doses postoperatively can be a very useful adjunct to other postoperative analgesics. Can also be used as a CRI (1–2 µg/kg/hr) and has been shown to provide analgesia when given epidurally (10 µg/kg).</td>
<td>Duke et al&lt;sup&gt;10,11&lt;/sup&gt;</td>
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<tr>
<td>Meloxicam&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1–0.2 mg/kg SC single dose</td>
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<tr>
<td>Meloxicam (oral)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.1 mg/kg PO on day 1, followed by 0.05 mg/kg PO daily for 4 days, then 0.05 mg/kg every other day or 0.025 mg/kg daily</td>
<td>This drug is particularly well received by cats because of its formulation as a honey-flavored syrup. When dispensed in drops, the dose is easy to decrease gradually and accurately. Clinical toxicity of long-term medication has not been evaluated, but it appears that even when the lowest effective dose is used, toxicity may be seen. Long-term administration at 0.05 mg/kg orally was recently approved in Europe for the control of musculoskeletal pain.</td>
<td>Lascelles et al&lt;sup&gt;12&lt;/sup&gt;</td>
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<sup>a</sup> (Table continues)
Table 1. Recommendations for Postoperative Analgesic Use in Catsa (continued)

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<tr>
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<th>Feline Doseb</th>
<th>Notes</th>
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<tr>
<td>Meperidine (pethidine)c</td>
<td>5–10 mg/kg IM q1.5–2h</td>
<td>Predictable analgesia, but short acting.</td>
<td>Balmer et al,k Lascelles et al,l Booth and Rankin,s Dixon et al,y Slingsby and Waterman-Pearsonz</td>
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<tr>
<td>Methadone</td>
<td>0.1–0.5 mg/kg IV or IM q4–5h</td>
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<tr>
<td>Morphine</td>
<td>0.1–0.5 mg/kg IM or slow IV q3–4h</td>
<td>Morphine may not be as effective in cats as in dogs and humans due to cats’ inability to form an active metabolite. However, this possible relative lack of efficacy may be overcome by using larger doses. This seems to vary from cat to cat. Also, morphine has a very slow onset in cats (&gt;1 hr) and may only last 3–4 hr.</td>
<td>Taylor et al,a Davis and Donnellybb</td>
</tr>
<tr>
<td>Morphine (oral liquid)</td>
<td>0.2–0.5 mg/kg tid or qid</td>
<td>Oral morphine is best compounded into a palatable syrup. However, cats usually significantly resent oral medication with morphine. Again, morphine may not be as effective in cats as it is in dogs.</td>
<td>—</td>
</tr>
<tr>
<td>Morphine (oral sustained release)</td>
<td>Not available in small enough tablets</td>
<td>—</td>
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<tr>
<td>Naloxone</td>
<td>0.005–0.010 mg/kg IV, SC, IM (dilute 0.1 mg naloxone in 12 ml sterile polyionic fluids and inject up to 0.25–0.5 ml/kg slowly IV, over several minutes, to effect)</td>
<td>Used to reverse opioid action and side effects. Should be titrated to effect. Note that the duration of action of naloxone is shorter than the duration of action of most opioids.</td>
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<tr>
<td>Piroxicam</td>
<td>1 mg/cat PO daily for a maximum of 7 days</td>
<td>Daily dosing for 7 days results in a slight increase in the half-life. The active drug decreases significantly over a 10-day period after compounding in an aqueous solution. In one author’s (BDXL) experience, significant drops in packed cell volume (presumably due to gastrointestinal hemorrhage) occur in up to 30% of cats after 2–3 wk of drug therapy.</td>
<td>—</td>
</tr>
<tr>
<td>Prednisolone</td>
<td>0.25–1.0 mg/kg PO q24h</td>
<td>Can be particularly effective in perioperative situations where there is significant inflammation. <strong>Do not combine with NSAID administration.</strong></td>
<td>—</td>
</tr>
<tr>
<td>Tolfenamic acidc</td>
<td>4 mg/kg SC or IM q24h up to 2 doses</td>
<td>—</td>
<td>Slingsby and Waterman-Pearsonm</td>
</tr>
<tr>
<td>Tolfenamic acid (oral)y</td>
<td>4 mg/kg PO q24h, maximum of 3 days</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
Table 1. Recommendations for Postoperative Analgesic Use in Cats\(^a\) (continued)

<table>
<thead>
<tr>
<th>Drug</th>
<th>Feline Dose(^b)</th>
<th>Notes</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vedaprofen</td>
<td>0.5 mg/kg PO q24h for 3 days</td>
<td>—</td>
<td>Lopez et al(^c)</td>
</tr>
<tr>
<td>Xylazine(^c)</td>
<td>0.05–0.1 mg/kg IV as needed</td>
<td>When combined with other sedative agents, this drug can cause significant cardiopulmonary changes. In the context of pain relief, xylazine is best used in small doses to augment other analgesics.</td>
<td>—</td>
</tr>
</tbody>
</table>

\(^a\)These recommendations are a summary of one author’s (BDXL) research and experience and may change as new research in this relatively new area of veterinary medicine is conducted and more is learned about the clinical toxicity of these drugs.

\(^b\)Always double check doses.

\(^c\)This drug is licensed and approved for use at the stated dose in the United States, the United Kingdom, mainland Europe, Australia, and New Zealand.


How to Make an Analgesic Wound Catheter

**Materials needed:**
- Ruler
- Scissors
- Polyethylene tubing (inner diameter, 0.03 inch [0.86 mm]; outer diameter, 0.05 inch [1.27 mm]; Intramedic (Becton Dickinson and Company, Sparks, MD) or red rubber catheter (5 French, 16 to 22 inches; not shown)
- Luer stub adapter (20 gauge)
- Match or lighter
- 3-ml syringe
- Hemostat (if a red rubber catheter is being used)
- Insulin syringe needle or 30-gauge needle
- Bacterial filter
- Injection port

**Making the catheter:**

**Step 1:** Measure and cut a piece of tubing to fit your needs (e.g., 1 ft [30 cm]) (Figure A).

**Step 2:** Place the Luer stub adapter at one end. This will be the “top” of the catheter. Seat the tubing as far as possible onto the adapter without any buckling. If the tubing buckles, it will usually leak later; therefore, remove the adapter, cut the catheter back a little, and start again.

**Step 3:** If using polyethylene tubing, light the lighter or match and quickly pass the “bottom” of the catheter (i.e., the end without the stub adapter) over the flame (Figure B). It does not take long to heat the tubing. Immediately pinch the heated end between two fingers to flatten and seal it. If using a red rubber catheter, clamp the bottom with a mosquito hemostat and heat the box-lock of the hemostat to melt the rubber and so seal the catheter.

**Step 4:** Test the seal just created by twisting the 3-ml syringe onto the stub adapter and trying to push air through the catheter. If the air leaks out, the bottom is not sealed well. Repeat step 3 until the bottom is completely sealed.

**Step 5:** Fenestrate the bottom end of the catheter over the desired length, using the insulin syringe or 30-gauge needle. For example, for a 1-ft catheter, start the fenestrations 3 inches (8 cm) from the bottom and work down to the bottom, staggering the holes about ¼ inch (5 mm) apart. Push the needle “through and through” to create the holes (Figure C). Rotate the catheter as you create each hole so that the holes are not in a line along one side of the catheter. When properly made, the catheter will leak droplets of anesthetic along the entire working surface (Figure D).

**Step 6:** Sterilize the catheter (gas or ethylene oxide sterilization) and label it with the total length of the catheter and the length of the fenestrations (e.g., 1 ft [3 in]). If a red rubber catheter is used, the catheter can be made at the time of surgery using sterile technique; however, a naked flame must not be used near the oxygen supply.

**Step 7:** Before using the catheter, attach the bacterial filter and injection port to the stub adapter (Figure E).

**Using the catheter:**

- Place the catheter in the deepest layer of the wound, making sure to position a portion of it over any transected large nerves. The catheter can be held in place with loose suture loops, but it should not be anchored with sutures. It should exit from the most dorsal part of the wound or from near one end of a long horizontal incision.

- Close the wound and administer the entire dose of 0.25% bupivacaine (1 to 2 mg/kg), diluted to an appropriate volume (i.e., a volume that will allow the anesthetic to spread all through the wound, but not so much as to possibly create wound problems). Alternatively, lidocaine can be administered at a continuous rate using a bulb reservoir or syringe pump, although this technique has not been described in cats.41 The syringe pump or bulb reservoir may not be compatible with the bacterial filter.

- When the anesthetic is discontinued, remove the catheter.

**Dosing regimen for bupivacaine:**

- Initial dose: 1 mg/kg at least 6 hours after surgery.

- Subsequent doses: 1 mg/kg/dose (cats: 0.5 mg/kg) at 6- to 8-hour intervals for as long as needed (usually 1 to 3 days). If the interval is longer than 6 hours on day 1 or longer than 6 to 8 hours on day 2, the bupivacaine will sting. Minimize this effect by injecting a small amount (approximately 0.25–1 ml)
to numb the area slightly before proceeding with the rest of the injection.

Possible concerns:

• Differential efficacy along wound: This technique appears to be very efficacious. However, sometimes parts of the wound appear to be receiving less anesthetic than others. This may have to do with catheter placement or obstruction of fenestrations.

• Obstruction of catheter: Occasionally, the catheter becomes blocked. This can be minimized by passing a small amount of heparinized saline through the catheter after administering the local anesthetic.

• Effect of repeated doses and volume on wound healing: Clinically, we have not encountered any adverse effects.

• Accumulation of bupivacaine: We are currently evaluating blood samples to see if bupivacaine accumulates in the systemic circulation. We have not encountered any clinical adverse effects.
Local Anesthetics

At our institution, we place an analgesic wound catheter in the surgical wound before complete closure. This catheter allows periodic instillation of a local anesthetic into the wound itself. Our experience suggests that cats with these catheters are more mobile and seem to have less pain after surgery, resulting in earlier discharge from the hospital. A recent study conducted in our institution demonstrated that the use of such analgesic catheters was associated with significantly decreased hospital stays.

Due to the retrospective design of the study, pain scores were not routinely recorded, but patient comfort was a major factor in the decision to discharge the patient. The shorter hospital stay would thus confirm our clinical impression that these catheters provide excellent analgesia. We have not experienced an increase in postoperative infections from these catheters. Because the cost of commercially available analgesic wound catheters is substantial, we have created a less expensive version (see the box on pages 726 and 727). The efficacy of and potential problems associated with these analgesic catheters are currently being evaluated in detail at our institution.

If local analgesic infusion catheters are to be used for pain control after surgery, their placement must be planned as part of the surgery. Any open-body cavities should be closed before wound catheter placement to prevent inadvertent leakage of local anesthetic into the body cavity. The anesthetic can then be administered aseptically through the port at scheduled intervals (Figure 8, Table 1). The use of a long-acting local anesthetic (i.e., bupivacaine) is recommended to decrease the number of injections given in one day. Alternatively, lidocaine can be administered at a continuous rate using a bulb reservoir or syringe pump, although this technique has not been described in cats. A well-placed analgesic catheter may substantially decrease the amount of injectable narcotic needed, resulting in less sedation and less nausea. For amputations, blocking nerves with a local anesthetic before sharp sectioning is recommended. Typically, the adjacent perineural fascia is infused with bupivacaine through a 25-gauge needle before sharp transection of the nerve (Table 1). Analgesic wound catheters should then be placed as close to the severed nerves as possible.

The major disadvantages of analgesic catheters compared with opioids are minor pain associated with local anesthetic administration (when the last dose was more than 6 to 7 hours previously and the block has worn off) and our reluctance to discharge these patients with the catheters in place. We have used these catheters with minimal complications in the past 4 years, but it should be noted that sublethal and fatal toxicities associated with lidocaine and bupivacaine have been reported in cats. We limit the total dose of local anesthetic in any cat to 4 mg/kg within 24 hours.

NSAIDs

NSAIDs are very effective in treating acute pain in cats. Care must be taken regarding the dose and dosing interval to avoid toxicity because there is considerable potential for NSAID toxicity in cats. The cat’s deficiency of glucuronidation pathways results in slow metabolism of several NSAIDs, particularly the phenolic compounds. With the appropriate dose and dosing intervals, however, NSAIDs can be used safely.

In recent years, a number of new NSAIDs have become available for veterinary therapy. Several of these have been investigated in cats and are now widely used for acute pain in the perioperative period and after trauma. Meloxicam, ketoprofen, and carprofen are all available in injectable forms and have demonstrated comparable analgesia in cats. In separate studies, single doses of meloxicam and carprofen provided significant postoperative analgesia. Meloxicam is licensed for use as a single perioperative dose. In our opinion, the licensed dose of 0.3 mg/kg is unnecessarily high. Doses of 0.1 to 0.2 mg/kg can provide good analgesia and increase the safety margin. There is no evidence-based information on what a safe follow-up regimen with NSAIDs would be in cats, and we recommend using only a single dose of injectable NSAID in these cases. Suggested doses of NSAIDs for multiple-day dosing are given in Table 1. Generally, we either use a single perioperative dose of an NSAID or start a short course of NSAID therapy 48 hours postoperatively. We choose the latter approach if we are concerned about the possibility of decreased renal perfusion during surgery or poor postoperative hemodynamics or if the patient becomes highly stressed in the clinic. The stress of anesthesia, surgery, and hospitalization can lead to gastrointestinal ulceration, and ulceration can worsen if an NSAID is administered. Of importance, we do not administer...
different NSAIDs sequentially—this practice may predispose the patient to gastrointestinal ulceration, as has been suggested in dogs.46

Contraindications for NSAID administration include renal disease, hypotension, anorexia, gastrointestinal disease, and heart disease. Although NSAIDs are effective for postoperative pain control, they are not recommended as the sole method of pain control in the immediate postoperative period for the surgeries described in this article.

Other Drugs
α₂-Agonists are best used as adjunctive analgesic drugs. Given in very low doses, they potentiate the effect of opioids. We typically give medetomidine as a CRI or as indicated during the first 24 hours after surgery. This helps to reduce the dose of narcotics needed and allows the cat to sleep comfortably the night after surgery. Ketamine, an N-methyl-D-aspartate antagonist,45 is also best used as an adjunctive analgesic drug. It is used to prevent spinal cord windup, which refers to neuromotor changes in the spinal cord secondary to nociceptive input. These changes can result in abnormal and exaggerated responses to noxious stimuli. We use ketamine mainly during the operative period because of the adverse behavioral effects associated with its use in the postoperative period.

Wound Care
The incision should be monitored at least once daily. Wound complications from extensive resections include infection, seroma formation, and dehiscence. Two large epidemiologic veterinary studies46,49 demonstrated a significant increased risk for postoperative wound infection associated with prolonged surgery and anesthesia. Animals undergoing a 90-minute surgical procedure are twice as likely to develop wound infections as are animals undergoing a 60-minute procedure, with infection rates doubling every hour thereafter.48 Extensive reconstructions take longer to perform, thus placing these cats at a particularly high risk for infection. Seroma and hematoma formation also predispose surgical wounds to infection.50 Care should be taken to minimize the duration of seromas by applying warm compresses as soon as a seroma is identified after surgery. Dehiscence of the surgical incision can be secondary to infection, motion, or excessive tension at the incision. The techniques described above should be used at surgery to eliminate any tension at the wound.

Nutrition
The importance of nutrition in patients recovering from surgery cannot be overemphasized. Nutrients are vital for wound healing and recovery from major surgery. Appetite stimulants may prove helpful in the immediate postoperative period. Some cats may require a feeding tube at surgery to ensure proper calorie intake. A nasoesophageal tube may permit short-term feeding but can be irritating to the nose and pharynx and cause anorexia itself. An esophagostomy or gastrostomy tube can be placed while the patient is under anesthesia.51,52 These large-bore tubes permit long-term feeding of nutritionally complete foods. The need to provide long-term feeding may be of greater concern in patients that have been hospitalized for a prolonged period of time (i.e., due to radiation therapy) or that are anorectic before surgery. Ruling out other causes of anorexia, such as organic disease, pain, or medications, is also critical during this time.

CONCLUSION
Surgical removal of FSAs in cats can be challenging, but with proper perioperative and surgical management, a successful outcome can be achieved. A review of 153 cats undergoing FSA resection found that 80.4% had a successful surgical outcome, defined as the lack of complications or death.40

REFERENCES


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