Analgesia for Small Animal Thoracic Surgery

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Abstract: Thoracic surgery in small animals is considered a painful procedure, resulting in alterations in pulmonary function and respiratory mechanics. Modifications in surgical approach and technique and selection of the appropriate analgesic protocol may improve outcomes in dogs and cats after thoracic surgery. Systemic administration of opioids and other agents, intercostal and intrapleural blocks, and epidural analgesia are among the most common options for pain management after thoracic surgery in small animals.

Thoracic surgery is associated with considerable postoperative pain in small animals, leading to hypoventilation, increased morbidity, prolonged hospitalization, and delayed recovery.1–10 Therefore, analgesia is indicated in all thoracic surgery patients to provide pain relief without interfering with respiration. The choice of surgical technique and analgesic protocol may affect the analgesic outcome in dogs and cats after thoracic surgery. Preemptive and multimodal analgesia are considered to be among the leading analgesic strategies for postthoracotomy pain in small animals. Most of the information presented in this article pertains to dogs due to the lack of research into pain associated with thoracic surgery in cats; however, information regarding cats has been included where available.

Effect of Surgical Technique
Access to the thoracic cavity may be obtained in many ways. The choice of thoracic approach is mainly determined by the type of intrathoracic damage or disease. Postoperative pain may be affected by the surgical approach (e.g., open thoracotomy versus thoracoscopy), the type of incision, and the technique of rib or sternebrae approximation for thoracotomy closure.2,9,10–15 Median sternotomy in dogs appears to be more painful than intercostal thoracotomy.10 Thoracoscopic surgery for pericardiectomy in dogs has been reported to cause less postoperative pain and morbidity than intercostal thoracotomy,15 possibly due to smaller incisions and reduced rib retraction resulting in less surgical trauma.

Pain after intercostal thoracotomy is mainly associated with intercostal nerve irritation.14 Muscle-sparing thoracotomy, which preserves the latissimus dorsi muscle, decreases morbidity without compromising exposure.16 However, further studies regarding pain and morbidity in small animals should be implemented to compare muscle-sparing intercostal thoracotomy with the traditional technique.

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Intense pain may develop during intercostal thoracotomy closure because the intercostal nerves are often trapped in the sutures that are placed circumcostal to the thoracotomy wound. Transcostal suture placement for thoracotomy closure has been reported to avoid nerve entrapment and appears to be less painful than the standard technique of circumcostal closure in dogs. Passage of the blunt end of the needle in close proximity to the rib during intercostal thoracotomy closure has been demonstrated to result in less nerve entrapment than other techniques. Suture type (wire versus polybutester) has been shown to have no effect on the degree of pain after median sternotomy closure in dogs. Surgical procedures and factors that contribute to pain after thoracic surgery in dogs and cats and the nerve supply involved are presented in Table 1.

**Pharmacologic Pain Relief After Thoracotomy**

**Regional Analgesia**

**Intercostal Nerve Block**

Selective intercostal block is employed before thoracotomy closure to alleviate pain and improve pulmonary function in small animals. Because of the overlapping nerve supply, two or three nerves on either side of the thoracotomy should be blocked. Selective intercostal block with a solution of 0.5% bupivacaine provides analgesia for up to 12 hours, and—compared with parenteral administration of morphine or oxymorphone—has minimal effect on postoperative blood gas values and minute ventilation in dogs undergoing intercostal thoracotomy. The bupivacaine 0.5% solution is injected caudal to the head of the rib near the insertion of the epaxial musculature and close to the intervertebral foramen. Doses of bupivacaine for intercostal blocks are shown in Table 2. The total dose of bupivacaine should not exceed 5 mg/kg. Intercostal nerve block has been recommended as an adjunct to systemic opioid therapy for the management of postthoracotomy pain, but it is not recommended for pain control after median sternotomy.

**Intrapleural Analgesia**

Intrapleural analgesia is achieved by placing local anesthetic between the visceral and parietal pleura to produce ipsilateral somatic block of multiple thoracic dermatomes. Diffusion of the anesthetic across the parietal pleura allows intercostal neural blockade by prohibiting the generation and conduction of nerve impulses. Local anesthetics can be given as a single injection, multiple injections, or a continuous infusion through an indwelling catheter placed intrapleurally.

Intrapleural administration of bupivacaine is used for pain relief after intercostal thoracotomy and median sternotomy in dogs. Localization of the block over dependent areas of the rib with changes in animal position suggests an influence by gravitational pooling. Use of this block is gaining popularity because a larger volume of bupivacaine can be used and no spinal or central effects are seen after induction. Bupivacaine 0.5% (1.5 mg/kg) is instilled through a thoracostomy tube; after instillation, the tube is flushed with saline solution. Because the bupivacaine is distributed by gravity, the animal is placed with the incision site down for up to 5 minutes. Intrapleural

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**Table 1: Factors Contributing to Postthoracotomy Pain**

<table>
<thead>
<tr>
<th>Surgical Procedure Involved</th>
<th>Nerve Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin incision</td>
<td>Thoracic and pectoral nerves</td>
</tr>
<tr>
<td>Muscle incision in intercostal thoracotomy (division of latissimus dorsi, scalenus, external abdominal oblique, and intercostal muscles)</td>
<td>Pectoral, thoracodorsal, intercostal, and cervical nerves</td>
</tr>
<tr>
<td>Muscle incision in median sternotomy (division of pectoral muscles)</td>
<td>Pectoral, cervical, and thoracic nerves</td>
</tr>
<tr>
<td>Rib spreading or fracture</td>
<td>Intercostal nerves</td>
</tr>
<tr>
<td>Intercostal nerve stretching, compression by retractors, sutures, or thoracostomy tubes</td>
<td>Intercostal nerves</td>
</tr>
<tr>
<td>Thoracic wall excision</td>
<td>Intercostal and thoracic nerves</td>
</tr>
<tr>
<td>Parietal pleura incision</td>
<td>Intercostal nerves</td>
</tr>
<tr>
<td>Thoracostomy tube placement</td>
<td>Thoracic, pectoral, thoracodorsal, and intercostal nerves</td>
</tr>
</tbody>
</table>

**Table 2: Doses of Bupivacaine 0.5% for Intercostal Blocks in Dogs and Cats**

<table>
<thead>
<tr>
<th>Animal Size</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small dogs (&lt;10 kg) and cats</td>
<td>0.25 mL/site</td>
</tr>
<tr>
<td>Medium dogs (&lt;25 kg)</td>
<td>0.5 mL/site</td>
</tr>
<tr>
<td>Large dogs (&gt;25 kg)</td>
<td>1 mL/site</td>
</tr>
<tr>
<td>Any size</td>
<td>0.3 mL/site for five sites</td>
</tr>
</tbody>
</table>

*Modified by the authors.*

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Median sternotomy appears to be more painful than intercostal thoracotomy in small animals.

**QuickNotes**

**Epidural Analgesia**

Analgesic agents may be injected into the spinal epidural space, most commonly through the lumbosacral space and close to the site of action (e.g., spinal cord receptors, spinal nerves) to achieve regional analgesia. Epidural analgesics may be administered as a bolus or by multiple injections through an epidural catheter to provide preemptive, intraoperative, and postoperative analgesia for thoracic surgery in dogs and cats. Local anesthetics, opioids, and other agents and combinations have been employed to provide analgesia using this technique.

Local anesthetics primarily block spinal nerve roots via a gravity effect. Bupivacaine is the most commonly used local anesthetic in small animals and has a longer duration of action than lidocaine or mepivacaine. Potentiation of the analgesic effect has been reported in dogs undergoing thoracotomy with combined epidural administration of bupivacaine and morphine. This synergy of opioids with local anesthetics may be the result of interaction with opioid receptors or diminished efferent nociceptive transmission facilitating the effect of opioids.

Epidural morphine administered preemptively has been reported to provide long-lasting analgesia in dogs and cats and is at least as effective as intercostal bupivacaine after intercostal thoracotomy in dogs. Morphine administered epidurally provides better analgesia than morphine given intravenously in dogs after intercostal thoracotomy. Epidural oxymorphone administered intraoperatively has been reported to provide better and longer-lasting analgesia in dogs than postoperative intramuscular oxymorphone. The increased lipid solubility of oxymorphone compared with morphine may provide more segmental analgesia for surgical procedures involving the hindlimbs and caudal abdomen; by contrast, epidural morphine—because of its more hydrophilic nature—may diffuse cranially and is more appropriate for providing analgesia for thoracic and cranial abdominal surgery.

Analgesic agents and their epidural doses for the relief of postthoracotomy pain in small animals are presented in Table 3.

**Systemic Analgesia**

Systemic analgesics can be adjuncts to other, more invasive analgesic strategies, especially when the latter are discontinued. Opioids administered parenterally are the primary form of systemic analgesia for thoracic surgery. Central respiratory depression is a potential adverse effect of opioid administration; however, because postthoracotomy pain may cause hypoventilation, systemic opioids may actually improve respiratory function by relieving the pain. Parenterally administered morphine (0.5 to 1 mg/kg SC, IM, or IV), oxymorphone (0.1 to 0.2 mg/kg IM or IV), or buprenorphine (10 μg/kg IV) can provide effective postoperative analgesia in dogs after intercostal thoracotomy or median sternotomy. Morphine

<table>
<thead>
<tr>
<th>Analgesic Agent(s)</th>
<th>Dose (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bupivacaine 0.5%</td>
<td>1</td>
</tr>
<tr>
<td>Morphine</td>
<td>0.1–0.4</td>
</tr>
<tr>
<td>Oxymorphone</td>
<td>0.1</td>
</tr>
<tr>
<td>Buprenorphine</td>
<td>0.003–0.006</td>
</tr>
<tr>
<td>Morphine + bupivacaine</td>
<td>(0.1–0.4) + (0.6–2)</td>
</tr>
<tr>
<td>Morphine + fentanyl</td>
<td>(0.1–0.3) + (0.01–0.2)</td>
</tr>
<tr>
<td>Bupivacaine + buprenorphine</td>
<td>(0.06–0.7) + (0.003–0.03)</td>
</tr>
<tr>
<td>Morphine + bupivacaine + fentanyl</td>
<td>0.1 + (0.06–0.1) + 0.01</td>
</tr>
</tbody>
</table>
and oxymorphone administration may cause hypoventilation, respiratory acidosis, and moderate hypoxemia in dogs, which (unlike humans) are relatively insensitive to the respiratory depressant effects of opioids. Systemic administration of buprenorphine has shown no effect on respiratory function in dogs. Fentanyl administered at a loading dose (2 to 5 μg/kg IV) before surgery and followed by continuous infusion intraoperatively (20 to 80 μg/kg/hr) and postoperatively (2 to 5 μg/kg/hr) provides adequate analgesia and allows for quick titration to increase the analgesic effect and decrease excessive hypoventilation.

Low-dose ketamine infusion administered at a loading dose (0.5 mg/kg IV) before surgery and followed by continuous infusion intraoperatively (10 μg/kg/min) and postoperatively (2 μg/kg/min) has been employed as an adjunct to preanesthesia morphine (1 mg/kg SC). This protocol can also be used as an adjunct to continuous intraoperative fentanyl infusion (1 to 5 μg/kg) to augment analgesia and comfort after forelimb amputation in dogs; it may also be used for postthoracotomy pain relief in small animals. Medetomidine (10 μg/kg IM) and other α₂-adrenergic agonists given postoperatively are thought to produce a better analgesic effect than buprenorphine (20 μg/kg IM) in dogs after intercostal thoracotomy.

NSAIDs are particularly useful for pain relief after thoracic surgery because they have no respiratory depressant effects. They are employed as adjuncts to systemic opioids or as part of a multimodal approach to pain management after thoracotomy. Postoperative administration of magnesium sulfate is reportedly associated with reduced morphine consumption for pain after thoracotomy in human patients. An algorithm for postthoracotomy pain control is presented in Table 4.

**Conclusion**

Several analgesic modalities are available for use in thoracic surgery in small animals, providing a range of choices to suit practice requirements and surgeon preference. These protocols can not only increase patient comfort but also improve pulmonary function during the critical period immediately after surgery.

**References**

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