Review Article

Post-thoracotomy analgesia

ABSTRACT

Thoracotomy is considered one of the most painful operative procedures. Due to anatomical complexity, post-thoracotomy pain requires multimodal perioperative treatment to adequately manage to ensure proper postoperative recovery. There are several different strategies to control post-thoracotomy pain including interventional techniques, such as neuraxial and regional injections, and conservative treatments including medications, massage therapy, respiratory therapy, and physical therapy. This article describes different strategies and evidence base for their use.

Key words: Analgesia; pain; postthoracotomy; thoracotomy

Introduction

Thoracotomy is normally considered one of the most painful operative procedures and postthoracotomy pain is often severe and can be difficult to manage.[1] Due to the anatomical distribution, the pain experienced by the patient is multifaceted and requires multimodal therapy to adequately manage. It is vital to control pain effectively in the perioperative setting (specifically considering preemptive analgesia) to ensure proper breathing, cough, and mobilization of the patient. Poor pain control can lead to poor recovery, infection, and respiratory failure. Proper pain control is also important to reduce the incidence of chronic post-thoracotomy pain syndrome (PTPS).[2] There are several strategies employed to control post-thoracotomy pain.

Management strategies include interventional techniques, like neuraxial injections and regional blocks, and conservative treatments, such as narcotic medications, nonsteroidal anti-inflammatory medications (NSAIDs), acetaminophen, gabapentinoids, and other adjunctive treatments including massage therapy, transcutaneous electrical nerve stimulation (TENS), respiratory therapy, and physical therapy.

Interventional Techniques

Thoracic epidural analgesia

Thoracic epidural analgesia (TEA) is used to manage thoracotomy pain. TEA is often utilized with moderate to large incisions or bilateral instrumentation and due to medication spread, is typically inserted in the middle of the dermatomal distribution of the incision.[3,4] Epidural analgesia is administered in the perioperative period through a single injection or catheter placement and infusion with patient-controlled epidural analgesia (PCEA) device. Placing the epidural catheter prior to general anesthesia allows assessment of its placement and efficacy.[4] Preemptive analgesia involves initiating analgesia preoperatively to prevent pain signal transmission during surgery.[5] Initiation of epidural analgesia prior to surgery is shown to improve

Access this article online	
Website: www.saudija.org	Quick Response Code
DOI: 10.4103/sja.SJA_743_20	

How to cite this article: Mijatovic D, Bhalla T, Farid I. Post-thoracotomy analgesia. Saudi J Anaesth 2021;15:341-7.

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Submitted: 10-Jul-2020, **Accepted:** 10-Jul-2020, **Published:** 19-Jun-2021

pain control postoperatively and decrease the incidence of chronic pain.[1,6,7] Epidural infusions typically consist of either local anesthetics, opioids, epinephrine, or a combination of these medications depending on patient characteristics.[3]

TEA has multiple benefits, including providing sufficient analgesia with decreased need for systemic opioids, decreased cardiopulmonary complications, decreased mortality, and decreased incidence of PTPS.[3,6,8] It is important to consider that TEA is associated with some procedure-related complications including potential spinal cord injury, infection, hematoma, postdural puncture headache, and catheter migration; however multiple studies have shown these complications to be rare.[3,9] Medication associated side effects can include nausea, vomiting, pruritis, bradycardia, hypotension, sedation, urinary retention, and respiratory depression.[1,3,9] TEA has shown superior pain control to parenteral opioids with less side effects.[1,3,10] TEA has similar analgesic efficacy to other interventional techniques including intrathecal analgesia (ITA) and paravertebral block (PVB).[3,4,11]

Limited data in the pediatric population has shown similar benefits of TEA in terms of pain control, safety, earlier mobilization and feeding, decreased postsurgical complications, and a similar side effect profile.[12-14]

Intrathecal analgesia

ITA is another common strategy to address thoracotomy associated pain. In thoracotomy, ITA is often used in combination with paravertebral catheters or second line if epidural is contraindicated.[4] ITA involves the administration of opioids typically directly into the cerebrospinal fluid (CSF) allowing the medication to directly bind opioid receptors in the spinal cord.[4,15] The speed, extent, and distribution of this spread is based on the lipophilicity of the medication administered.[4] Preservative-free morphine (PFM) is commonly used, but other opioids including fentanyl and hydromorphone are utilized as well.[15] ITA can be administered in a single injection or catheter placement with similar efficacy in the short term.[4,16] Intrathecal catheter placement has several possible complications including neurological injury, CSF leaks, infection risk.[17] Patients receiving single injection ITA typically require multimodal or combination analgesia with parenteral narcotics or regional block due to short duration of action of PFM.[4,18]

ITA has also been shown to be effective for post-thoracotomy analgesia and allows decreased opioid requirements postoperatively compared to parenteral opioids.[19] Common side effects of intrathecal opioids include pruritis, respiratory depression, nausea, vomiting, postdural puncture headaches, and urinary retention with pruritis being the most common and respiratory depression being most life-threatening.[4,15,19-21] ITA is more effective than opioid PCA alone.[16,22,23] When compared to TEA, several studies show similar benefits and side effects except for a higher risk of respiratory depression with ITA.[11,20]

In the pediatric population, ITA can be used safely and effectively in combination with a multimodal analgesic approach with similar benefits and risks as mentioned in the adult literature.[24,25]

Paravertebral block

More recently, PVBs have gained popularity as another strategy to address thoracotomy pain. PVB involves administering an anesthetic agent in a single injection or catheter infusion into the paravertebral space, which is formed by the parietal pleura anterolaterally and costotransverse ligament posteriorly, through which the spinal nerves pass from the intervertebral foramen to the intercostal space.[4,9,26] Studies have shown dermatomal spread up to 10 dermatomes depending on anesthetic agent and volume injected with preferential caudal spread, but certain patients may require multiple injections.[9,26] Typically, PVB is considered a unilateral block, but due to epidural spread, a small percentage of patients may experience bilateral analgesia or sympathetic blockade.[26] Most clinicians will use local anesthetic with or without epinephrine.[26] PVB is usually considered overall safer and easier than TEA and is often considered when thoracotomy is unilateral, however bilateral PVB can also be performed.[26] Drawbacks to the procedure include lack of familiarity for clinicians, variable anesthetic spread, anesthetic leak out of the space, and the necessity for opioid supplementation.[4,26]

There is evidence that PVB is effective for pain control in thoracic surgery and is comparable to TEA for post-thoracotomy pain with a similar safety profile and less side effects.[1,27-29] Common complications and side effects of PVB include nerve injury, vascular puncture, dural puncture, hypotension, pleural puncture, and pneumothorax.[26,28,29]

Due to anatomical differences in children compared to adults, ultrasound guidance is often utilized to ensure proper technique.[30] In the pediatric population, PVB has been shown to be an effective and safe option for post-thoracotomy analgesia.[31,32]

Serratus anterior plane block

The serratus anterior plane block (SAPB) has also recently become more popular options for post-thoracotomy

analgesia. This ultrasound-guided block is performed by administering a local anesthetic to the potential space between the serratus muscle and the intercostal nerves at the T4-T5 level resulting in unilateral anterior thorax analgesia potentially spanning T2-T9.[9,33] These blocks are shown to be effective in managing post-thoracotomy pain and can decrease opioid requirements postoperatively.[9,34,35] However, SAPB is not as effective for post-thoracotomy analgesia as PVB, especially after 12 hours postoperatively.[34,36] Overall, there seems to be a lower complication rate when compared to TEA and PVB, but common complications include hypotension, bradycardia, and pneumothorax.[34,36]

In the pediatric population, SAPB can be used effectively to manage post-thoracotomy pain and is shown to be superior to intercostal nerve blocks.[37,38]

Erector spinae block

Erector spinae block (ESB) is an ultrasound-guided peripheral nerve block where local anesthetic is injected between the erector spinae fascia and transverse process causing the medication to spread to the paravertebral space resulting in analgesia.[39,40] Studies in cadavers and live patients have shown multidermatomal level spread up to seven levels cranially and caudally.[40,41] ESB has several complications including pneumothorax, bowel injury, nerve damage, local anesthetic systemic toxicity (LAST), and block failure.[42] In pooled studies, ESB is shown to be an effective strategy for post-thoracotomy pain in combination with a multimodal analgesia regimen.[39,41] When compared to traditional analgesia strategies, ESB has shown similar pain control to TEA and PVB with lower instances of bradycardia and hypotension, but higher rates of analgesic failure.[42-44]

Several case studies in the pediatric population have demonstrated tolerability, safety, and efficacy of ESB in managing post-thoracotomy pain and decreasing opioid demand.[41,45,46]

Intercostal nerve block

Intercostal nerve block (ICB) is a simple and direct method to provide analgesia. Typically, local anesthetic is injected directly up to five intercostal nerves corresponding to the dermatomes affected by the incision.[1] These can be performed by the surgeon with direct visualization in the pleural or percutaneously by the anesthesiologist but are often limited by a short duration of action and often require repeat injections.[1,4] ICB has been shown to decrease postoperative opioid requirements.[1] However, ICB have been shown to be inferior to TEA for post-thoracotomy analgesia.[47] Complications of ICB include pneumothorax, LAST, bleeding, nerve injury, and block failure.[1]

Small studies have shown ICB to be effective and safe in the pediatric population with similar complication rates.[48-50]

Cryoablation

A related strategy to ICB is cryoablation where intercostal nerves are frozen to -60°C to interrupt pain signaling by damaging the myelin sheath but keeping the nerve axon intact.[9,51] Cryoablation has been reported to provide improved pain control, decreased opioid requirements, and less pulmonary complications when compared to ICB or parenteral opioids.[51-53] Complications of the procedure are mostly related to nerve damage and there is some evidence that cryoablation may be associated with increased risk for chronic pain and PTPS months after ablation.[1,51,54,55] When compared to epidural analgesia, cryoablation required more opioids and resulted in worse pain control.[51]

Recent small studies in the pediatric population have shown benefit in pain control, decreased length of stay, and lower risk of complications, chronic neuropathic pain, or PTPS when compared to the adult population.[56-58]

Interpleural block

Interpleural analgesia involves injecting local anesthetic between the parietal and visceral pleura of the lung.[59] There is little evidence showing this to be an effective analgesic technique in thoracotomy pain. It is believed that postoperative blood in the pleural cavity and systemic absorption of the medication decreases the effectiveness of the procedure.[4] The lack of benefit has been shown in multiple studies and this technique is not recommended for post-thoracotomy pain.[4,60-62]

Shoulder pain and interscalene block

Despite a well-performed block, patients may still have referred shoulder pain related to thoracotomy or chest tube placement, typically called Kehr's Sign. This referred pain is mediated by the phrenic nerve (C3-5) and is not normally covered by any of the analgesic techniques described in this section. Due to the supraclavicular nerves that originate from the same nerve roots as the phrenic nerve, this pain may be addressed with an interscalene brachial plexus block.[9] Interscalene block is shown to reduce post-thoracotomy shoulder pain without impairment of pulmonary function.[63,64]

Conservative Techniques

Medications

As mentioned before, due to the complex etiology of post-thoracotomy pain, it is important to apply a multimodal strategy in post-thoracotomy analgesia. This strategy should include interventional and regional analgesia in

combination with systemic medications.[4,65] Medications most used include opioids, NSAIDs, acetaminophen, and more recently gabapentinoids. There is some recent evidence for ketamine as a part of a multimodal analgesia strategy.

Due to the high doses required using opioids as sole agents, they are typically used in conjunction with regional techniques and nonopioid analgesics to provide adequate analgesia to avoid postoperative complications of uncontrolled pain.[4] Several opioids are used including morphine, fentanyl, hydromorphone, methadone, and tramadol. The addition of methadone to a multimodal analgesia strategy has been shown to decrease opioid requirements and improve pain scores postoperatively.[66,67] Opioids can be administered orally or parenterally through patient-controlled analgesia (PCA) or on-demand dosing. Intravenous opioid PCA has been shown to provide better analgesia with less total dosage than on-demand parenteral opioids.[68-70] If regional anesthesia techniques are contraindicated, there is evidence that pain can be adequately controlled using a combination of parenteral opioids in combination with nonopioid medications.[71] While in general, opioids are effective at controlling pain, this must be balanced with the potential side effects of respiratory depression, sedation, itching, nausea, vomiting, urinary retention, constipation, and ileus.[72]

Ketamine infusion has been recently studied as an adjunctive analgesic medication in the perioperative period.[73] Ketamine can be added to opioids to effectively decrease postoperative pain and opioid requirements without significant worse side effects.[74-76]

NSAIDS are commonly used postoperatively as they simultaneously decrease pain and inflammation.[4] NSAIDs are part of a multimodal strategy to control pain and have been shown to decrease total opioid consumption and improve pain scores.[72,77] Selective cyclooxegenase-2 (COX-2) inhibitors are sometimes preferred to nonselective NSAIDs due to lower risk of bleeding and gastrointestinal side effects.[72] Acetaminophen is a commonly used analgesic for mild to moderate pain and can be administered orally, rectally, and parenterally.[72] When compared to oral, intravenous acetaminophen has the benefit of faster analgesic onset and lack of first-pass metabolism, but high cost and risks of intravenous administration must be considered.[78] Acetaminophen can be used in combination with other analgesics with an additive effect.[4] NSAIDs and acetaminophen can both target ipsilateral referred shoulder pain.[4,73,79]

Due to the significant neuropathic component to post-thoracotomy pain and subsequent chronic PTPS, gabapentinoids including gabapentin and pregabalin have been used to specifically target this type of pain. Studies of gabapentinoids in post-thoracotomy analgesia have shown improved pain control, refractory chest wall pain relief, decreased opioid use, and reduced risk of chronic PTPS.[55,72,80-83] Unfortunately, due to the heterogeneity of studies, there is no clear recommended regimen.[72] Side effects of gabapentinoids include dizziness, somnolence, sedation, and blurry vision.[72]

Adjunctive Treatments

In addition to regional anesthesia techniques and medication, there is some evidence that adjunctive treatment strategies can be beneficial. Massage therapy has been shown in one systematic review to decrease pain scores after thoracotomy.[84] In combination with traditional post-thoracotomy analgesia, TENS has been shown to decrease pain and analgesic consumption without significant side effects or prolongation of hospital stay.[85-87] However, these benefits seem to be short-lived and only last while the TENS is in use.[88] Similarly, cold therapy in the form of ice packs can be used to decrease incisional pain and inflammation and decrease opioid requirements.[89]

Physical and respiratory therapy is an important part of thoracotomy recovery. Patient positioning is important to consider and early upright sitting and ambulation can improve lung function and recovery.[89] Posture correction, shoulder and scapula mobilization, and thoracic mobilization will help return patients to normal functioning.[89,90] Lung expansion and clearing techniques including deep breathing, incentive spirometry, coughing, huffing, and breath control can improve functional recovery, decrease atelectasis, and decrease postoperative complications.[89,90]

Conclusion

Adequate perioperative management of thoracotomy pain is important to ensure good outcomes, decreased postoperative complications, improve mobilization, and decrease the risks of chronic pain. There are multiple strategies that can be used depending on patient characteristics and clinician expertise. In general, due to the multifactorial nature of post-thoracotomy pain, it is important to employ a multimodal analgesia strategy that can include neuraxial or peripheral regional analgesia, opioids, gabapentinoids, NSAIDs, acetaminophen, and adjunctive mechanical treatments.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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