THE ROLE OF REGIONAL ANESTHESIA IN THORACIC SURGERIES

Dr. Loran Mounir Soliman, M.D.
Director, Regional Anesthesia Fellowship
Director, Peripheral Nerve Analgesia Service
Division of Anesthesia, Critical Care and Comprehensive Pain Management
Cleveland Clinic

OBJECTIVES:

At the conclusion of this presentation, the participant will:
1. Be able to discuss the benefits and limitations of regional anesthesia for thoracic surgeries.
2. Recognize the recent advancements in methods and techniques of regional anesthesia.
3. Recognize the different modalities of regional anesthesia and their role in a multimodel analgesic plan for thoracic surgeries.
4. Compare outcomes of regional anesthesia versus general anesthesia for thoracic anesthesia.

Introduction:
One of the main challenges in anesthesia for Thoracic Surgery is the peri-operative pain control. The severity of both acute and chronic postoperative pain and their effects on the cardiopulmonary physiology is unique among other surgeries. Adequate understanding of the anatomy of thoracotomy pain as well as its detrimental effect on the respiratory and cardiovascular systems is essential for the appropriate pain management in thoracic surgery.

Possible sources of nociceptive input that may contribute to postoperative pain following thoracic surgery are multiple and include the site of the surgical incision; disruption of the intercostals nerves; inflammation of the chest wall structures adjacent to the incision, pulmonary parenchyma, or pleura; and thoracotomy drainage tubes. Unrelieved acute
pain following thoracic surgery may contribute not only to postoperative pulmonary
dysfunction, but also to the development of postthoracotomy pain syndrome.
It is estimated that at least half of all patients still alive 1-2 years after thoracotomy will
suffer with this persistent chest wall pain. Furthermore, as much as 30% of patients may
still experience pain 4-5 years after surgery\textsuperscript{1}

Thoracotomy pain is complex, often involving 6 to 7 dermatomes eliciting inflammation
in several areas including the chest wall, the pleura, the diaphragm, the lungs, the
mediastinum and the pleural space.
It involves noxious input, which is conveyed to the CNS along the intercostals nerves, the
vagus, and phrenic nerves. In fact, afferent phrenic activity is thought to be the source of
the shoulder pain that frequently occurs because it is curtailed by phrenic block but not
by epidural or suprascapular block.
The intercostal nerves are subject to multiple insults and their dysfunction result form
incision, retraction, trocar placement or suture and probably plays an important role in the
acute and chronic pain associated with thoracic surgery.
During thoracotomy, the lateral chest wall is incised, tissue dissected, and a retractor is
placed in an intercostal space to separate the ribs and enable surgical access.
Thoracotomy by a standard posterolateral approach is presumably associated with greater
intercostals nerve damage and pain than by a muscle-sparring thoracotomy. The classic
posterolateral thoracotomy involves division of the latissimus dorsi at its midportion after
a lateral incision at the 5\textsuperscript{th} IC space. Division of the latissimus dorsi can be avoided with
a muscle sparing approach, which involves a less-disfiguring vertical incision made at the
mix-axillary line. In addition to the cosmetic benefits, muscle-sparing incisions have
been shown to decrease pain in some people due to less IC nerve disruption.
The last contributing insult to the IC nerves is the need for constant respiratory effort and
pulmonary toilet, which produces an intense noxious input to the CNS.

Perhaps the most profound effect of thoracic surgery is its impact on pulmonary function.
There is a major reduction in FRC due to diaphragmatic dysfunction, decreased chest
wall compliance, and pain-limited inspiration. As a result the FRC decreases at least by
20% and up to 50% leading to ineffective cough, poor inspiration. As Phil Bromage \(^2\) showed years ago, reflex inhibition of the phrenic nerve can impair diaphragm activity and it continues for 5 – 7 days postoperatively. This reflex inhibition is not affected by the use of systemic or epidural opioids. However, thoracic epidural with local anesthetics can improves pulmonary function by blunting spinal reflex arcs, controlling pain and increasing chest wall compliance. An important meta-analysis published in JAMA (2003) reviewed 100 studies comparing epidural to IV opioids\(^3\). Pain was measured after abdominal surgery, thoracic surgery and lower extremity. The authors combined all the studies and observations and used weighted mean difference in analgesia. They concluded that epidural analgesia provided statistically and clinically significant improvement in postoperative pain control compared with parenteral opioids, regardless of analgesic regimen (LA with or without opioid or opioid alone), site of epidural catheter placement in relation to surgical incision, or measured pain outcomes. They recommended that thoracic epidural should be used as a “gold standard” analgesic modality for thoracic surgeries.

**Cardio-vascular effects of thoracic epidural:**
Cardiac complications are the most common cause of mortality and morbidity after thoracic procedures. Thoracic epidural analgesia using local anesthetics can produce a selective segmental block of the cardiac sympathetic innervations (T1-T5). Since perioperative high sympathetic activity plays a causative role in the development of myocardial ischemia and infarction, inhibition of this activation would be expected to reduce cardiac morbidity by increasing supply and reducing demand\(^4\).

There are several large studies involving high-risk patients that report significant reductions in cardiac morbidity associated with the use of intraoperative and postoperative epidural analgesia. This may occur by several mechanisms—blockade of sympathetic efferent signals, enhanced fibrinolytic activity, and systemic absorption of local anesthetics. The clinical relevance of this phenomenon is confirmed by convincing data that intra-operative epidural improves graft patency in lower extremity vascular reconstruction patients\(^5\).
Anthony Rodgers and colleagues reviewed a 141 randomized trials with almost 10,000 patients. They demonstrated a significant improvement in mortality when either spinal or thoracic epidural analgesia was used without GA. Overall mortality was reduced by 1/3 in patients allocated to neuraxial blocks. Regional anesthesia also reduced the odds of DVT, PE, transfusion requirements, pneumonia, and respiratory depression.

It was their conclusion that central neuraxial anesthesia techniques could reduce perioperative morbidity, including DVT by 44%, PE by 55%, MI by 33%, and stroke by 15%, as well as mortality by 30%.

It is important to emphasize that the beneficial effects of regional anesthesia on cardiac morbidity could be limited to thoracic epidural techniques rather than the lumbar techniques. This can be explained by the fact that surgical trauma is accompanied by stress response that includes sympathetic activation and higher levels of catecholamines. Patients with coronary artery disease are at particular risk with stress and high sympathetic activity. A thoracic epidural with local anesthetics can produce a segmental blockade of cardiac sympathetic innervations (T1-T5) and reduce the stress response, which may have a protective effect on the heart.

Although total coronary blood flow typically remains unchanged with thoracic epidural, blood flow to ischemic areas of myocardium may increase. Thoracic epidural analgesia also reduces the major determinants of myocardial O2 demand (blood pressure, heart rate, SVR).

**Respiratory Effects of Thoracic Epidural:**
Regional Anesthesia can reduce the incidence of postoperative atelectasis, pneumonia, and hypoxemia by improving the ability of early chest exercise as well as ambulation. Better pain control with local anesthetics can lead to less sedation by avoiding opioids, which allow early extubation. Ballanytne et al concluded that regional analgesia with local anesthetics can improve pulmonary outcomes by attenuating the physiologic response to surgery, controlling postoperative pain, permitting earlier extubation, and reducing length of hospital stay. In this meta-analysis, thoracic epidurals provided
superior analgesia with less atelectasis, pulmonary infection and overall pulmonary complication. Also PO2 levels were higher in most of the studies using thoracic epidural catheters.

**Risk of epidural hematoma with full anti-coagulation:**

Epidural analgesia is not without risk, the most devastating complication is epidural hematoma which can ends by permanent paraplegia if not treated immediately. Anesthesiologists are especially concerned with cardiothoracic patients who often receive full heparin dose, placed on cardiopulmonary bypass and treated with anti-platelets. We recently reviewed the literature for both lumbar and thoracic epidurals placed for adult and pediatric patients undergoing cardiothoracic surgeries with or without CPB. Many studies had reported the safety of epidural catheter placement in patients undergoing cardiopulmonary bypass. The number of reported cases is insufficient to calculate the risk of epidural hematoma associated with regional anesthesia followed by cardiopulmonary bypass. Ho et al. structured a mathematical model based on 4583 epidural and 10,840 spinal anesthetics used for cardiac procedures. They estimated the maximum risk of epidural hematoma to be 1 : 1528 for epidural blocks and 1 : 3610 for subarachnoid blocks. The minimum risk estimate is 1 : 150 000 for epidurals and 1 : 220 000 for subarachnoid blocks. In our review, thoracic epidural catheter placement was associated with fewer serious complications than lower thoracic or lumber epidural placement. The reason for this probably resides in the increased distance from nerve roots involved in the lower extremity, bowel & bladder function.

There are no guidelines for the optimal timing of epidural catheter placement in relation to cardio-pulmonary bypass, however the (ASRA) American Society of Anesthesiologists guidelines can help as general rules. The guidelines state that heparin administration should be delayed for 1 h after needle or catheter placement. Catheters should be removed in the absence of coagulopathies and 1 h before any subsequent heparin administration or 2–4 h after the last heparin dose.

Early recognition of spinal cord compression is of critical value in determining the neurological recovery following surgical decompression. The use of a low concentrated solution of local anesthetics or even restricting to use only epidural opioids.
intraoperatively allows early neurological evaluation postoperatively.

**Peripheral Nerve Blocks:**
For patients undergoing thoracotomy, thoracic paravertebral block (PVB) is a good alternative to thoracic epidural. It carries less risk of serious complications (spinal cord injury, epidural hematoma or abscess). A single shot as well as indwelling catheter can be places unilaterally as well as bilateral. A catheter can be placed surgically in the paravertebral space deep to the endothoracic fascia and brought out of the chest by a separate intercostal puncture. It can be also placed percutaneously as well, using a Touhy needle 2.5 cm lateral to the rostral edge of the appropriate spinous process. When the needle comes in contact with the rostral edge of the transverse process, it is then walked off it and slowly advanced until a loss of resistance is felt indicating the penetration of the costotransverse ligament. After aspiration to confirm the needle is extravascular, 20-30 ml of local anesthetics is injected to open up the paravertebral space and to facilitate threading a catheter into the space. The major complication aside from failure is Pneumothorax, which is usually not of a concern in thoracic patients who presumably have a chest tube already in place.

Intercostal nerve blocks are another easy to perform regional anesthesia technique that can supplement incomplete thoracic epidurals and paravertebral catheters. Often times, the chest tube site is the main hurting dermatome in an otherwise good functioning block. A small blunt needle is used to walk off the lower edge of the desired ribs anywhere along its course between the transverse process and the Post. Axillary line. Once the needle is walked off the bone, aspiration is performed and 5 ml of local anesthetics in injected. Multiple spaces can be blocked in order to block the affected dermatomes.

**Conclusion:**
Cardiothoracic surgeries are associated with significant amount of pain, which may affect the post-operative course of these patients. Regional Anesthesia (thoracic epidural, paravertebral, and intercostals nerve blocks) provides an excellent pain control after cardio-thoracic surgeries. The adequate analgesia in addition to the sympathectomy induced by regional anesthesia can improve the mortality and morbidity due to their
effects on the cardiovascular and respiratory systems in addition to the prevention of post-thoracotomy pain syndromes.

Further studies are needed to quantify the safety of regional anesthesia in cardio-thoracic surgeries.

References: