Regional Anesthesia in Cardiothoracic Surgery: Can We Fix an Achy Breaky Heart?

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Learning Objectives

1) Identify appropriate candidates for regional anesthesia in cardiothoracic surgery
2) Review relevant anatomy for various regional techniques
3) Describe different regional techniques for sternotomies, minimally invasive mitral valve surgery, VATS, and thoracotomies
4) Discuss regional anesthesia options for pectus excavatum repair

Presentation Format

This presentation will be divided into 2 sections:

1) Regional anesthesia for cardiac surgery
   - Open heart surgery/sternotomy
   - Minimally invasive cardiac surgery
2) Regional anesthesia for thoracic surgery
   - VATS and robotic surgery
   - Thoracotomy
   - Lung Transplant
   - Pectus excavatum repair

Disclosures

- We have no disclosures

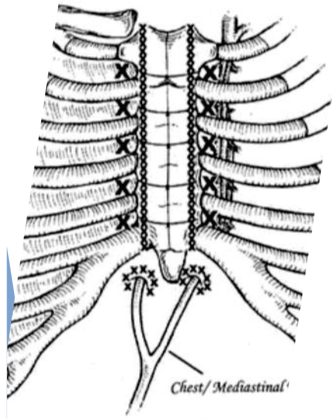
Regional Anesthesia for Open Cardiac Surgery

History of Median Sternotomy

- First described in 1897 on a live goat (and it survived!)
- Dr. Ormand Julian in Chicago published a series of successful median sternotomy cases on human patients in 1957
- Sternotomy remains the most popular surgical access to the heart
  - Tide is turning towards more minimally invasive techniques
- Opioids have remained the analgesic method of choice for perioperative sternotomy pain BUT this approach may be shifting, as well

Sternotomy Pain

- Severe pain often persists for several days following sternotomy
- Uncontrolled pain is often associated with myocardial ischemia, respiratory complications, and higher rates of mortality
- Lahtinen et al looked at severe pain reporting on post op day 4:
  - At rest: 49%
  - During movement: 62%
  - With coughing: 78%
- Chronic post-sternotomy pain syndrome (PSPS)
  - Defined as consistent sternal pain for 2 months after surgery
  - Kalso et al reported PSPS in 28% of CABG patients, with 38% of those patients reporting pain as moderate to severe
  - Van Gulik et al found that 35% of sternotomy patients had PSPS



Parasternal Block

- McDonald et al publishes surgeon performed parasternal block in 2005
  - Field block using 54mL of 0.25% levobupivacaine:
    - 2 mL at each of the 5 interspaces bilaterally, just lateral to sternum
    - Line of local infiltration along the periosteum on the lateral borders of the sternum: 12 mL per side
    - 10 mL of local was infiltrated around the mediastinal tubes
  - Block patients had lower morphine requirements and lower pain scores
    - Plasma concentration levels of bupivacaine were below the toxic level

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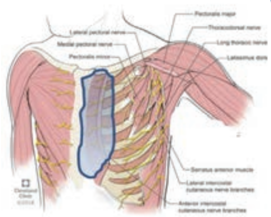
Evolution of Parasternal Block

- Ultrasound has led to a more "modern day" targeted approach
- Block target:
  - Anterior cutaneous branches of intercostal nerves T2 to T6
- Analgesia to sternum and medial chest wall



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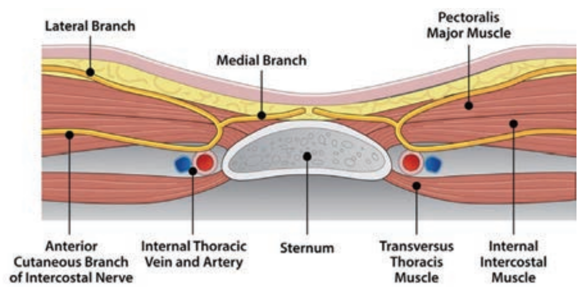
Relevant Anatomy



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Parasternal Intercostal Plane Block

Nomenclature

- ASRA-ESRA published a Dephi Consensus study in 2021 aiming to standardize the nomenclature for abdominal, paraspinal and thoracic wall blocks
- Superficial Parasternal Intercostal Plane block (SPIPB)
  - Formerly called pecto-intercostal fascial plane block
- Deep Parasternal Intercostal Plane Block (DPIPB)
  - Formerly called transversus thoracic muscle plane block

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How is it performed?

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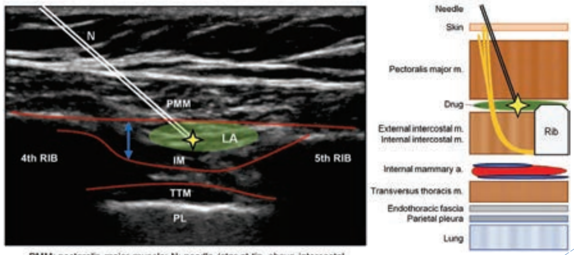
Superficial Parasternal Intercostal Plane Block

- Injectate between pectoralis major and intercostal muscle



PMM: pectoralis major muscle; N: needle (star at tip, above intercostal muscle); IM: intercostal muscle; LA: local anesthetic (green); TTM: transversus thoracis muscle; PL: pleura.

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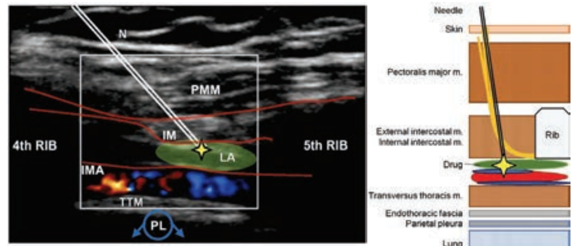
Deep Parasternal Intercostal Plane Block

- Injectate between intercostal muscle and transversus thoracic muscle



PMM: pectoralis major muscle; N: needle (star at tip, below intercostal muscle); IM: intercostal muscle; LA: local anesthetic (green); TTM: transversus thoracis muscle; PL: pleura; IMA: Internal mammary artery.

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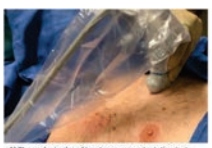
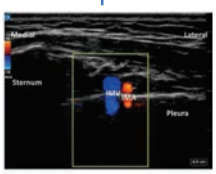
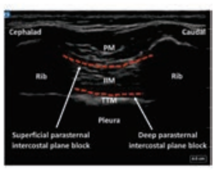
Parasternal Block Technique



A) The probe is placed in a transverse orientation just superior to the nipple line at approximately the third or fourth rib and just lateral to the sternum. The internal mammary artery and vein are visualized.



B) The probe is rotated 180° in a caudal-cephalad orientation. The probe is then moved medial to the site where the internal mammary artery and vein were identified. Local anesthetic is deposited in the appropriate plane.



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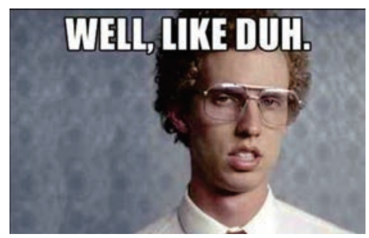
But, does it work?



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Supporting evidence

- Aydin et al (2020) compared DPIPB to sham block
  - Lower opioids in first 24 hours and at every time point up to 24 hours
  - Longer time to rescue analgesia in DPIPB patients
- Khera et al (2021) compared SPIPB to sham block
  - Lower but not statistically significant opioid requirements in first 48 hours
  - Statistically significant pain score reduction in SPIPB group (2.6 vs 4.8)
- Zhang et al (2021) compared SPIPB to sham block
  - Less sufentanil and parecoxib consumption
  - Lower pain scores at rest/coughing
  - Decreased time to extubation, shorter ICU/hospital stays
  - Lower insulin, glucose, IL-6 and HOMA-IR levels 3 days postop

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Which block approach is better?

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Comparison of Ultrasound-Guided Pecto-intercostal Fascial Block and Transversus Thoracic Muscle Plane Block for Acute Poststernotomy Pain Management After Cardiac Surgery: A Prospective, Randomized, Double-Blind Pilot Study

Cengiz Kaya, MD, Burhan Dost, MD, Ozgur Dokmeci, MD, Semih Murat Yucel, MD, Deniz Karakaya, MD

- Compared SPIPB vs DPIPB
- First 24-hour morphine use did not significantly differ between the 2 groups
- No difference between in NRS scores at rest and during coughing
- Similar requirements for rescue analgesia in the first 24
- The time from PCA to the first analgesia request was longer in the SPIPB group than in the DPIPB group

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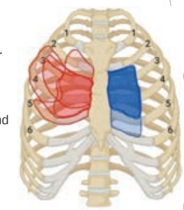
Superficial versus deep parasternal intercostal plane blocks: cadaveric evaluation of injectate spread

Rachel N Douglas [1], Punnose Kattil [2], Nirusha Lachman [2], Rebecca L Johnson [1], Adam D Niesen [1], David P Martin [1], Matthew J Ritter [3]

- Single 20 ml injection SPIPB & DPIPB at T3-4 interspace in four fresh frozen cadavers
  - Cephalocaudal spread was greater with DPIPB
  - Lateral spread extended to the midclavicular line for all DPIPB and beyond the midclavicular line for all SPIPB
  - Neither block extended to the rectus sheath inferiorly

Due to proximity of injection location to the internal mammary artery, study authors proposed that the DPIPB be classified as an "advanced block" and recommended that future studies focus on optimizing superficial parasternal intercostal plane parasternal spread



Red: SPIPB; Blue: DPIPB

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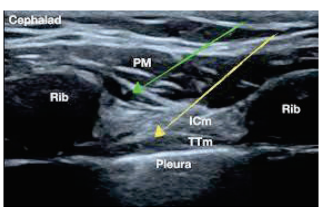
Potential drawbacks of DPIPB

- Transversus thoracic muscle is very thin and can be difficult to visualize
- Internal mammary artery (IMA) and vein pass through the transversus thoracic plane, leading to potential vascular injection or injury
  - Vascular damage is especially detrimental for IMA harvesting in CABG surgery
- Pleura and pericardium are deep to the target plane



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Safety profile of DPIPB

Safety of Ultrasound-Guided Transversus Thoracis Plane Block in Pediatric Cardiac Surgery: A Retrospective Cohort Study

Ibrahim Abdelbaser, MD, Nabil A. Mageed, MD

- 236 pediatric patients received DPIPB
- Left-sided pleural and pericardial puncture occurred in 1 patient (0.5%)
- One patient (0.5%) developed a self-limiting small subcutaneous hematoma
- Pneumothorax, injury of internal mammary vessels, cardiac injury, and hemopericardium were not directly observed
- No patient developed an allergy to local anesthetic, hypoxia, bradycardia, or hypotension after local anesthetic injection
- Post-sternotomy neuropathic pain was not recorded in any patient

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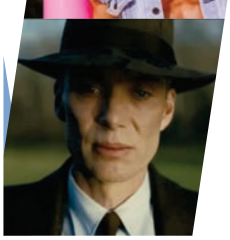
Advantages of Superficial Parasternal Intercostal Block

- More superficial
- Easier and faster to perform (probably)
- Fewer potential complications



Advantages of Deep Parasternal Intercostal Block

- Works very well
- Greater cephalocaudal spread with single injection

CRASH

Block timing?

- Padala et al compared preoperative and postoperative parastemal block efficacy
  - No difference in pain scores in first 24 hours
  - Intraoperative fentanyl requirements lower in preoperative block group
  - Total opioid requirements similar in first 24 hours
  - Time to extubation was higher in preoperative block group

CRASH

Parasternal catheters

Continuous Pecto-Intercostal Fascial Block Provides Effective Analgesia in Patients Undergoing Open Cardiac Surgery: A Randomized Controlled Trial

Yang Zhang [1], Jia Min [1], Shibiao Chen [1]

- RCT of 116 patients with bilateral SPIPB catheters undergoing median sternotomy
- Dermatomal spread measured to be T1-T7 distribution
- Resting and dynamic pain scores significantly lower through 72 hours

Take home points

- Parasternal block is an exciting new ultrasound technique
- SPIPB is more approachable due to its ease, efficacy, and safety profile
- Amenable to catheter placement
- Can be performed preop to minimize intraop opioids or postop for rescue analgesia
- ERAS and/or fast track protocol potential when combined with multimodal analgesia
- Case reports suggest parasternal blocks are useful for sternal fracture analgesia after CPR, motor vehicle trauma, etc
- More studies needed to optimize technique and ideal usage

Regional Anesthesia for Minimally Invasive Cardiac and Thoracic Surgery

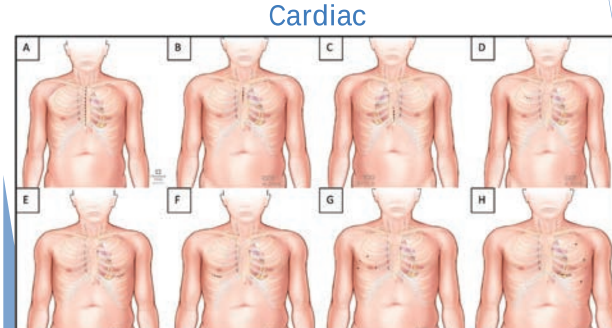
Benefits of Minimally Invasive Surgery

- Smaller incisions
- Decreased blood loss
- Lower risk of infection
- Faster recovery
- Decreased length of stay
- Less postoperative pain

Minimally Invasive Techniques: Cardiac

- Partial upper/lower sternotomy
- Right anterior thoracotomy
- Right/Left anterolateral thoracotomy
- Robotically assisted

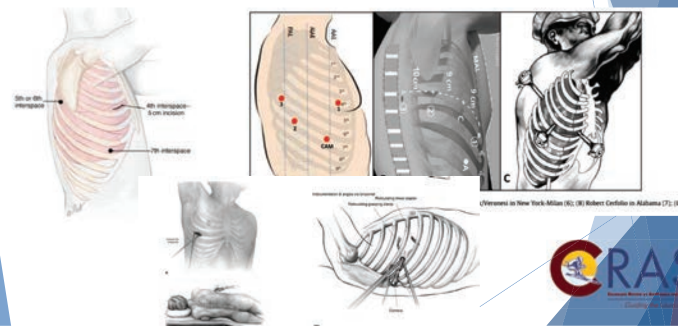
Minimally Invasive Techniques: Cardiac



Minimally Invasive Techniques: Thoracic

- Video Assisted Thoracoscopic Surgery (VATS)
- Robotic Assisted Thoracoscopic Surgery (RATS)

Minimally Invasive Techniques: Thoracic



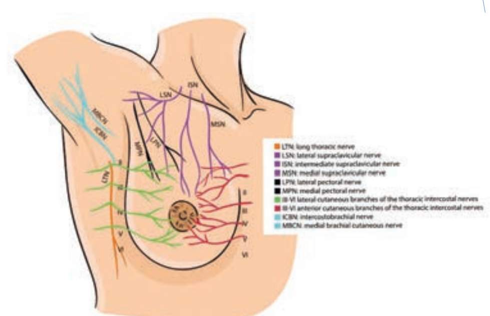
Minimally Invasive- So Why Block?

Mini thoracotomy
Damage to intercostal neurovascular bundle from port sites
Chest tubes

Uncontrolled pain following cardiothoracic surgery

- Splinting
- Pulmonary complications (pneumonia)
- Mechanical ventilation and prolonged ICU stay
- Opioid side effects
- Chronic postoperative pain syndrome
  - **30% can still develop post-thoracotomy pain syndrome (PTPS) after VATS**

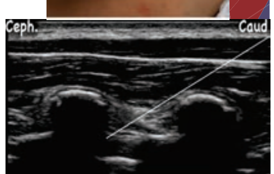
Review of Chest Wall Innervation



Paravertebral Nerve Block

- Ipsilateral analgesia
- Spread ~1-3 levels above and below level of injection
- Targets spinal nerves (intervertebral foramina), ventral and dorsal rami
- Less hemodynamic changes compared to epidural

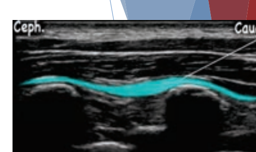
- More technically challenging to perform
- Considered deep block- same anticoagulation guidelines as epidural
- Risk of pneumothorax

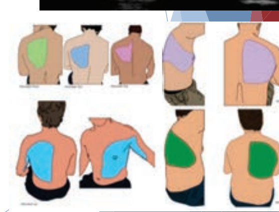


Erector Spinae Block

- Large volume plane block
- Local spreads within potential space over 3-6 vertebral levels
- Dorsal rami and (ideally) ventral rami
- Spread to paravertebral and (sometimes) epidural space

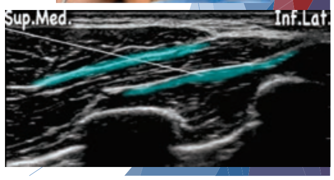
- Considered safe with anticoagulation
- Low risk for adverse events (pleural injury, hematoma, nerve injury etc)
- Downside- spread is variable, especially to anterior thorax





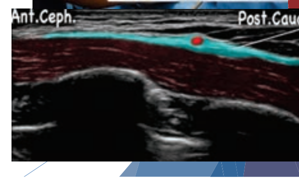
PECS I/II Block

- Large volume plane block
- Blocks:
  - Lateral/Medial pectoral nerves
  - T2-6 lateral cutaneous intercostal nerves
  - Thoracodorsal nerve
  - Long thoracic nerve
  - Intercostobrachial nerve
- Supine
- Safe, anticoagulation not issue
- Need to identify thoracoacromial artery



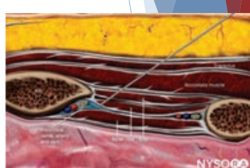
Serratus Anterior Block

- Large volume plane block
- Can inject superficial or deep to serratus anterior muscle
- Blocks:
  - T3-9 lateral cutaneous intercostal nerves
  - Thoracodorsal nerve
  - Long thoracic nerve
- Supine
- Safe, anticoagulation not issue



Intercostal Nerve Block

- Typically performed by surgeon under direct visualization
- Require multiple levels
- Blocks:
  - Intercostal nerve (anterior and lateral cutaneous branches if blocked posteriorly enough)
- Multiple injections
- Shorter duration of action
- Risk for LAST



Evidence - Regional MIS Cardiac

Erector Spinae and MIS Cardiac


Journal of Cardiothoracic and Vascular Anesthesia

Original Article

The Use of Unilateral Erector Spinae Plane Block in Minimally Invasive Cardiac Surgery

Michael Morkos, MD, Aidan DeLeon, MD, Michael Koeckert, MD, Zachary Gray, MPAS, PA-C, Kenneth Liao, MD, Wei Pan, MD, Daniel A. Tolpin, MD

- 2022 retrospective, nonrandomized study- ESP vs no block
- 129 pts undergoing R/L robotic assisted thoracotomy (valve vs CABG)
  - 86 pts received ESP block post induction and catheter placed
  - 43 pts received no block
- Primary outcome: 48 hr opioid consumption
  - Significant reduction in ESP group (30.24 mg +/- 23.8 mg vs 47.82 mg +/- 53.6 mg, p=0.04)
- Length of ICU and hospital stay also decreased
- Conclusion: ESP can safely improve postoperative measures

Erector Spinae and MIS Cardiac


Journal of Cardiothoracic and Vascular Anesthesia

Case Report

Continuous Erector Spinae Plane Block as an Effective Analgesic Option in Anticoagulated Patients After Left Ventricular Assist Device Implantation: A Case Series

Sanjib Das Adhikary, MD, Amit Prasad, MD, Behzad Soleimani, FRCS, MRCP, Ki Jinn Chin, MBBS (Hons), FRCPC

- 2018 case series- 5 patients receiving/explanting LVAD
- 4 of 5 cases, ESP with catheter performed as rescue analgesia 1-7 days postop
- 1 case received ESP with catheter preoperatively
- All experienced reduction in pain scores/opioid consumption and had improved respiratory dynamics
- No adverse events reported

Erector Spinae and MIS Cardiac

Journal of Clinical Anesthesia

Efficacy of erector spinae plane block for minimally invasive mitral valve surgery: Results of a double-blind, prospective randomized placebo-controlled trial

- 2023 RCT- ESP for MIS mitral valve surgery (R sided mini-thoracotomy)
- 72 pts – all received ESP catheter at end of case
  - 31 pts 30 mL Ropi 0.5% bolus + 3 additional 20 mL boluses 6 hr intervals
  - 31 pts 30 mL NS bolus + 3 additional 20 mL boluses 6 hr intervals
- Primary outcome: 24 hr opioid consumption after extubation
  - No difference (41 mg vs 37 mg)
- Secondary outcomes: duration of postop ventilation, severity of pain, hospital LOS
  - No differences noted
- Conclusion: adding ESP block to standard multimodal does NOT reduce opioid consumption

PECS II + ESP and MIS Cardiac

BMC Anesthesiology

RESEARCH ARTICLE Open Access

Postoperative pain treatment with erector spinae plane block and pectoralis nerve blocks in patients undergoing mitral/tricuspid valve repair — a randomized controlled trial

- 2020 RCT- ESP vs ESP + PECS for MIS mitral/tricuspid valve repair (R mini-thoracotomy)
- 30 pts- 15 pts ESP + PECS vs 15 pts ESP only
- Primary outcome: total oxycodone consumption in first postoperative day
  - ESP + PECS used significantly less oxycodone (12 mg vs 20 mg p=0.0004)
- Secondary outcomes: pain intensity (VAS), patient satisfaction, spirometry
  - Pain intensity significantly less in ESP + PECS
  - Patient satisfaction higher in ESP + PECS
  - No difference in spirometry
- Conclusion: adding PECS to ESP reduces opioid consumption, pain intensity and increases patient satisfaction

PECS II vs PVB and MIS Cardiac

Journal of Cardiothoracic and Vascular Anesthesia

Original Article

Pectoral Fascial Plane Versus Paravertebral Blocks for Minimally Invasive Mitral Valve Surgery Analgesia

- 2023 retrospective, PECS II vs PVB in robotic mitral valve surgery
- 313 patients- 123 pts received PECS II, 190 pts received PVB
- Primary outcome: cumulative opioid use and average pain scores
  - PECS II group required significantly less opioids in immediate postop period (41.5 mg vs 50.5 mg morphine equivalents in first 12 hrs), comparable postop pain scores
- Secondary outcomes: hospital and ICU length of stay, incidence of complications
  - No increase in adverse outcomes noted between groups
- Conclusion: PECS II block is safe and effective analgesic option for patients undergoing robotic mitral valve surgery

PECS and MIS Cardiac:

STUDY PROTOCOL Open Access

The impact of PECS II blockade in patients undergoing minimally invasive cardiac surgery—a prospective, randomized, controlled, and triple-blinded trial

Elisabeth Hoerner, Ottokar Stundner, Felix Naegele, Anna Fiala, Nikolaos Bonaros, Peter Mair, Johannes Holfeld and Lukas Gasteiger

Serratus Anterior and MIS Cardiac

Journal of Cardiothoracic and Vascular Anesthesia

Original Article

The Serratus Anterior Plane Study: Continuous Deep Serratus Anterior Plane Block for Mitral Valve Surgery Performed in Right Minithoracotomy

- 2020, observational cohort study- SAB vs IV morphine in MIS mitral valve sx
- 59 pts- 33 received SAB, 26 received IV morphine
- Primary outcome: pain evaluation and total postoperative opioid consumption
  - Mean NRS at 48 hrs less in SAB group (1.77 vs 3.23, p=.003)
  - SAB used significantly less opioid postoperatively (2.22 mg vs 12.98 mg, p<0.001)
- Secondary outcomes: incidence of PONV, time to extubation, mechanical ventilation duration, bowel dysfunction
  - No significant differences
- Conclusion: deep SAB catheter require less opioids and is valid alternative to IV opioids

Serratus Anterior and MIS Cardiac

BMC Anesthesiology

RESEARCH ARTICLE Open Access

Serratus anterior plane block for minimal invasive heart surgery

Vivien Berthoud, Omar Ellouze, Maxime Nguyen, Maria Konstantinou, Serge Aho, Ghislain Malapert, Claude Girard, Pierre-Grégoire Guinot, Olivier Bouchot and Belaid Bouhemad

- 2018 retrospective, SAB vs continuous wound infiltration in MIS cardiac sx
- 46 pts- 20 pts SAB, 26 pts CWI
- Primary outcome: morphine consumption and VAS for first 48 hrs
  - SAB used significantly less morphine (11 mg vs 21 mg, p<0.01)
  - VAS significantly lower at h0, not significant in following hours
- Secondary outcomes: length of ICU and hospital stay, PONV, NIV
  - Shorter ICU and hospital stay in SAB group
  - No difference observed in PONV or need for noninvasive ventilation
- Conclusion: SAB effective in decreasing opioid use after MIS cardiac surgery

PECS + SAB and MIS Cardiac

Ultrasound-Guided PECS II + Serratus Plane Fascial Blocks Are Associated with Reduced Opioid Consumption and Lengths of Stay for Minimally Invasive Cardiac Surgery: An Observational Retrospective Study

- 2022 retrospective, PECS + SAB vs IV opioids in MIS R minithoracotomy
- 78 pts- 41 pts PECS (30 mL) + SAB (30 mL), 37 pts IV morphine or tramadol
- Primary outcome: pain perceived, opioid consumption
  - PECS + SAB had significantly less perceived pain at 6, 12 and 24 hrs and total opioid consumption
- Secondary outcomes: mechanical ventilation time, ICU stay, PONV, respiratory depression
  - Significantly shorter intubation and ICU stay, less PONV and resp depression but not significant
- Conclusion: PESC + SAB provide superior pain control compared to IV opioids

PECS + SAB and MIS Cardiac

Serratus anterior and pectoralis plane blocks for robotically assisted mitral valve repair: a randomised clinical trial.

Alfirevic, Andrej; Marciniak, Donn; Duncan, Andra E; Kelava, Marta; Yalcin, Esra Kutlu; Hamadnalla, Hassan; Pu, Xuan; Sessler, Daniel I; Bauer, Andrew; Hargrave, Jennifer; Bustamante, Sergio; Gillinov, Marc; Wierup, Per; Burns, Daniel J P; Lam, Louis; Turan, Alparslan

ISSN: 0007-0912 , 1471-6771; **DOI:** 10.1016/j.bja.2023.02.038; **PMID:** 37055276

British journal of anaesthesia : BJA. , 2023, Vol.130(6), p.786-794

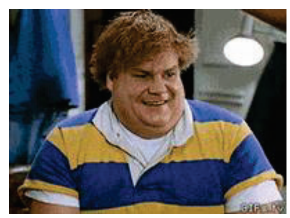
- 2023 RCT- PECS + SAB vs standard analgesia in robotically assisted mitral valve
- 194 pts- 98 pts PECS + SAB (bupi + liposomal bupi), 96 pts routine analgesia
- Primary outcome: overall benefit analgesia score (OBAS)
  - No benefit over POD 1-3
- Secondary outcomes: opioid consumption, respiratory mechanics
  - No evidence of treatment effect on opioid consumption or resp mechanics
- Conclusion: PECS + SAB do NOT improve postop analgesia after robotically assisted mitral valve repair

Intercostal Nerve Block and MIS Cardiac

Intercostal Cryo Nerve Block in Minimally Invasive Cardiac Surgery: The Prospective Randomized FROST Trial

- 2021 RCT- intercostal cryo nerve block vs standard of care MIS valve sx via thoracotomy
- 84 pts- 65 pts CryoNB, 19 pts SOC
- Primary outcome: 48 hr postop FEV1
  - CryoNB had higher FEV1 (1.2 vs 0.93 L, p=0.02)
- Secondary outcomes: VAS, ICU and hospital length of stay, total opioid consumption, chronic postop pain
  - VAS scores, ICU and hospital length of stay similar
  - Overall reduction in opioid use in CryoNB compared to SOC
- Conclusion: intercostal CryoNB improves FEV1 postoperatively and provides analgesia

Best Block for Minimally Invasive Cardiac Surgery?



Evidence – Regional MIS Thoracic

PROSPECT Guidelines for VATS


Anaesthesia 2022, 77, 311-325 doi:10.1111/anae.15609

Guidelines

PROSPECT guidelines for video-assisted thoracoscopic surgery: a systematic review and procedure-specific postoperative pain management recommendations

S. Feray,[1] J. Lubach,[2] G. P. Joshi,[3] F. Bonnet[4] and M. Van de Velde[5] on behalf of the PROSPECT Working Group *of the European Society of Regional Anaesthesia and Pain Therapy

- 2022 systematic review, PROSPECT guidelines for VATS
- RCTs between 2010-2021 included, total of 69 RCTs and 2 reviews
- Made recommendations on multimodal analgesia, peripheral nerve blocks
- Summaries of the nerve blocks to follow….

Paravertebral Block and VATS

- Total of 19 studies evaluated
  - Catheters placed by surgeons: all demonstrated decreased opioid use in PVB group
  - Single shot PVB: all with either decreased opioid use and/or pain scores compared to IV opioid or local wound infiltration
  - PVB vs ICB: one demonstrated lower pain scores in PVB, one no difference
  - Adding precedex: most demonstrated improved analgesia compared to LA alone
  - Intermittent vs cont infusion: one with no difference, one with improvement in pain scores
  - Multiple levels vs single level: no difference in pain score, more painful with multiple
- Conclusion: paravertebral nerve block is recommended in VATS

Erector Spinae and VATS

- Total of 9 studies evaluated
  - SS ESP vs no block: improved pain scores and less opioid use in first 24 hrs
  - SS ESP vs sham: decreased pain scores and opioid use in all but one study which had less opioid rescue analgesia in sham group
  - ESP vs PVB: showed ESP equivalent in analgesia and opioid consumption in several, two showed PVB was superior
  - Adding precede: showed improved pain scores and less rescue analgesia
- Conclusion: ESP is recommended in VATS

Serratus Anterior and VATS

- Total of 14 studies evaluated
  - SAB vs no block: SAB significantly improved pain scores and decreased opioid consumption
  - SAB vs sham: lower pain scores in SAB and decreased opioid consumption
  - SAB vs local infiltration: better pain scores in first 8 hrs
  - SAB vs ICB: two studies did not see significant difference in pain scores/opioid use
  - SAB vs ESP: two showed equivalence, one showed ESP superior in pain control
- Conclusion: SAB is good alternative for VATS if not able to do PVB or ESP

Intercostal Nerve Block and VATS

- Total of 3 studies evaluated
  - ICB vs no block: significantly lower pain scores
  - Additives: longer pain control with decadron and precede than ropi alone
- Conclusion: not recommended given lack of procedure specific evidence

Best Block for Minimally Invasive Thoracic Surgery?

- Paravertebral or Erector Spinae Block
- Serratus Anterior is a good backup

Regional Anesthesia for Thoracotomy

Regional Anesthesia for Thoracotomy

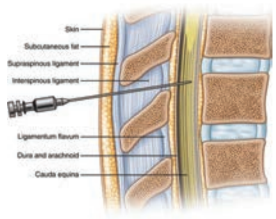
- Describe 3 common regional anesthesia techniques for thoracotomy
  - Epidural
  - Paravertebral block
  - Erector Spinae Plane block
- Identify appropriate candidates for each technique
- Compare efficacy between techniques: what does the data show?

Why is it important?

- Uncontrolled postoperative pain following thoracotomy can lead to atelectasis, reduced pulmonary function, hypoxemia, and infection
- Risk of chronic postsurgical pain from thoracotomy is increased with inadequate postoperative analgesia
- Strategies:
  - Multimodal analgesia
  - Regional techniques

Thoracic epidural anesthesia (TEA)

- Previously regarded as the gold standard for analgesia for thoracotomy
- Most effective when placed preoperatively and initiated intraoperatively
  - Utilize multimodal analgesia including opioids as needed
- Continue postoperatively until removal of chest tube(s)

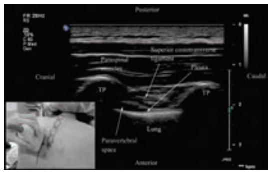


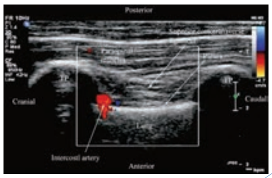
https://aneskey.com/spinal-and-epidural-anesthesia-2/

Thoracic epidural anesthesia

- Common contraindications include:
  - Coagulopathy
  - Infection
  - Patient refusal
- Risks:
  - Perioperative hypotension
  - Inadequate analgesia
  - Nerve injury
  - Hematoma and infection
- Incidence of failure and hypotension decreased by:
  - PCEA vs continuous TEA only
  - Presence of dedicated pain service

Paravertebral nerve block (PVB)

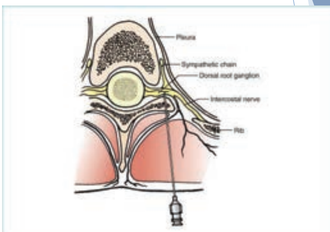




https://www.nysora.com/ultrasound-guided-thoracic-paravertebral-block/#toc_4--ULTRASOUND-GUIDED-TPVB

Paravertebral nerve block

- Single shot nerve block vs catheter
  - Catheter preferred for thoracotomy
- Advantages over TEA:
  - Unilateral coverage of hemithorax
  - Less risk of perioperative and postoperative hypotension and other side effects
- Disadvantages
  - Less spread of LA
  - Pleural integrity?



https://aneskey.com/paravertebral-block-3/

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Paravertebral nerve block

- Contraindications similar to TEA:
  - Coagulopathy
  - Infection
  - Patient refusal or intolerance to procedure
- Risks
  - Pneumothorax
  - Inadequate analgesia
  - Nerve injury
  - Hematoma and infection
  - Hypotension less common than TEA

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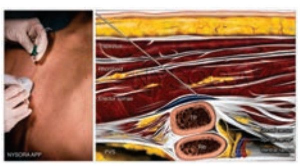
Erector Spinae Plane block (ESPB)

- Single shot nerve block vs catheter
  - Catheter preferred for thoracotomy at T4 or T5 transverse process
- Ideal alternative for coagulopathic patients
- Safer and faster than PVB
- Disadvantages
  - Less consistent coverage of visceral pain (pleura, chest tube)
  - Density of neural blockade



https://www.nysora.com/erector-spinae-plane-block/

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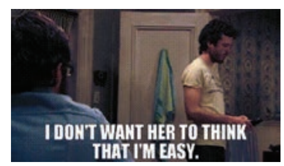
Erector Spinae Plane block

- Contraindications
  - Infection
  - Patient refusal
- Risks
  - Inadequate analgesia
  - Nerve injury
  - High spread
  - Infection
  - Hematoma unlikely to cause further complications



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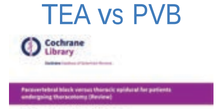
Which one should we choose?

CRASH

TEA vs PVB



- 2016 Cochrane review compared TEA vs PVB for adults undergoing elective thoracotomy
  - 14 studies totaling 698 participants
- Moderate evidence: PVB as effective as TEA in controlling acute pain
  - PVB reduced risk of minor complications
- No differences in major complications, 30-day mortality, or LOS
- 7 of 10 studies finding PVB=TEA had no opioid in epidural

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TEA vs PVB

- Meta-analysis by Beattie et al (2001) of 17 studies with 1,173 patients showing significant reduction in postoperative MI
- Decrease in supraventricular arrhythmias
- Evidence for decreased incidence of post-thoracotomy pain syndrome with TEA
  - Lack of studies for PVB – trial ongoing


Epidural Analgesia Reduces Postoperative Myocardial Infarction: A Meta-Analysis

The Effects of Three Different Analgesia Techniques on Long-Term Postthoracotomy Pain

Acute Pain after Thoracic Surgery Predicts Long-Term Post-Thoracotomy Pain

Randomised controlled pilot study to investigate the effectiveness of thoracic epidural and paravertebral blockade in reducing chronic post-thoracotomy pain: TOPIC feasibility study protocol

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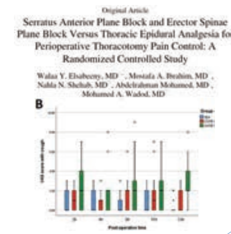
ESPB for thoracotomy

- Elsabeeny et al (2021)
  - RCT of 51 patients comparing ESPB, serratus anterior plane block (SAPB), and TEA
- VAS score at rest and with cough significantly lower for TEA compared to SAPB
  - Similar for TEA vs ESPB
- Significantly lower morphine consumption for ESPB compared to SAPB


Original Article

Serratus Anterior Plane Block and Erector Spinae Plane Block Versus Thoracic Epidural Analgesia for Perioperative Thoracotomy Pain Control: A Randomized Controlled Study

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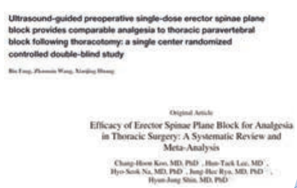
ESPB for thoracotomy

- Fang et al (2019)
  - Single center RCT of 91 patients compared ESPB with PVB in thoracotomy
  - No significant differences in pain scores or opioid consumption at rest and with cough at 1, 6, 12, and 24h
- Chang-Hoon et al (2021)
  - Meta-analysis with 17 studies and 1,092 patients
    - VATS and thoracotomy
  - ESPB statistically inferior to PVB and ICNB, superior to SAPB
    - Clinical significance unclear


Ultrasound-guided preoperative single-dose erector spinae plane block provides comparable analgesia to thoracic paravertebral block following thoracotomy: a single center randomized controlled double-blind study

Original Article

Efficacy of Erector Spinae Plane Block for Analgesia in Thoracic Surgery: A Systematic Review and Meta-Analysis

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Summary of recommendations – regional anesthesia for thoracotomy

- TEA and PVB with catheter remain the gold standard – how to decide?
  - Dependent on experience of anesthesiologist; institutional preference
  - PVB may be preferable in centers without dedicated acute pain service
- ESP catheter is a safe and generally effective alternative in coagulopathic patients
  - Recommend bolus dosing for catheter

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Regional anesthesia for lung transplantation

- Approximately 4500 lung transplants performed annually worldwide
- Considerations: single vs double lung transplant and incision type
- Adequate analgesia has benefits in reducing pulmonary complications, promoting early mobilization, and potentially decreasing ICU LOS and risk of post-thoracotomy pain syndrome
- TEA has been considered the gold standard for analgesia, but there is increasing evidence for alternative methods

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TEA for lung transplantation

- Preoperative vs post-operative placement?
  - Preop: Concern for anticoagulation, CPB, "bloody tap"
  - Postop: lack of preemptive analgesia, difficult positioning, placement under heavy sedation, postop coagulopathy
- Considerations: single vs double lung transplant, need for cardiopulmonary bypass


REGIONAL ANAESTHESIA

Regional analgesia for lung transplantation

A narrative review

Azem, Karam; Mangoubi, Eitan; Zribi, Benjamin; Fein, Shai

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TEA for lung transplantation: evidence

- Mclean et al (2018), 163 pts
  - Preop vs post-op: less opioid consumption and shorter ICU LOS
- Axtell et al (2018), 103 pts
  - Preop vs post-op: improved analgesia, no change in morbidity
- Cason et al (2015), 123 pts
  - Post-op only, improved analgesia without added morbidity
- Studies not adequately powered for most severe complications

Assessing the Benefits of Preoperative Thoracic Epidural Placement for Lung Transplantation

Sean R. McLean, MD, Peter von Homeyer, MD, Aaron Cheng, MD, Michael L. Hall, Michael S. Mulligan, MD, Kevin Cain, PhD, Kei Togashi, MD, MPH

Pain management and safety profiles after preoperative vs postoperative thoracic epidural insertion for bilateral lung transplantation

The Efficacy and Safety of Epidural-Based Analgesia in a Case Series of Patients Undergoing Lung Transplantation

PVB for lung transplantation: evidence

- Advantages/disadvantages comparable to TEA in thoracotomy
- Lack of studies for PVB
- Lenz et al (2017), 44 pts
  - Retrospective cohort study
  - TEA and PVB comparable in efficacy, both superior to systemic analgesia
- Hutchins et al (2017), 35 pts
  - Prospective observational study
  - PVB catheters efficacious for single and double lung transplant

Application of Continuous Wound-Infusion Catheters in Lung Transplantation: A Retrospective Data Analysis

Paravertebral Catheter Use for Postoperative Pain Control in Patients After Lung Transplant Surgery: A Prospective Observational Study

Jacob Hutchins, MD, Ioanna Apostolidou, MD, Sara Shumway, MD, Rosemary Kelly, MD, Qi Wang, MS, Cody Foster, MS, Gabriel Loor, MD

ESPB for lung transplantation: evidence

- Advantages/disadvantages comparable to TEA in thoracotomy
  - Relative safety in the setting of coagulopathy of greater importance in this population
- Lack of studies for ESPB
- Limited to case reports describing improved analgesia and decreased supplemental oxygen requirement

Continuous Erector Spinae Plane Block for Analgesia after Thoracotomy for Lung Transplantation in an Anticoagulated Patient

Other blocks: serratus anterior plane, parasternal, and intercostal nerve blocks

- SAPB limited to case reports
  - Improved analgesia and decreased opioid consumption
- ICNB
  - ICN cryoablation: reversibly inhibits nerve function results in long-term analgesia
  - Park et al: cryoablation better than ICNB but inferior to TEA in thoracotomies
- No published studies for parasternal blocks in lung transplantation

Summary of recommendations – regional anesthesia for lung transplantation

- Currently more evidence to favor TEA over PVB
  - Preop vs post-op: risk/benefit discussion
  - Double lung transplant: increased dermatomal coverage required
  - More studies for PVB needed
- Effectiveness of ESPB unknown – further studies needed
  - Not useful for sternotomy
  - Consider in coagulopathy
- ICNB cryoablation
  - May be useful
  - Concern for development of neuralgia

Regional Anesthesia for Pectus Excavatum Repair

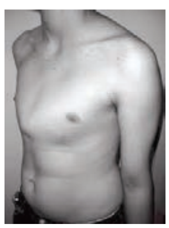
Pectus Repair: Making Stabby Things Feel Better

Alan R. Bielsky MD
Associate Professor, Anesthesiology, University of Colorado School of Medicine
Executive Director of Pain Services, Children's Hospital of Colorado

- Most common chest wall deformity
- Can affect pulmonary capacity
- Rarely with cardiac effects

www.topdoctors.co.uk

- Scoliosis
- Marfan syndrome
- Mitral valve prolapse,
- Homocystinuria
- Morquio syndrome,
- Noonan syndrome
- Osteogenesis imperfecta



Shamberger RC, Welch KJ. Surgical correction of pectus carinatum. Journal of pediatric surgery. 1987 Jan 1;22(1):48-53.

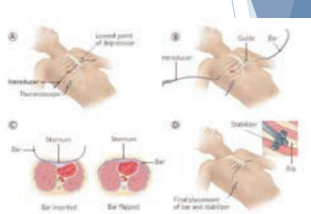
Clinical Characteristics: Haller Index

- *distance 1* = distance of the inside ribcage (at the level of maximum deformity or at the lower third of the sternum)
- *distance 2* = distance between the sternal notch and vertebrae
- Haller Index= D1/D2

Wikipedia/Stepshep 2008

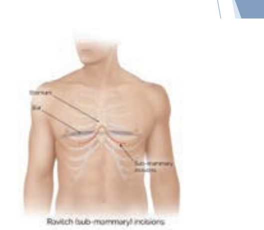
Daunt S, Cohen J, Miller S. Age-Related Normal Ranges for the Haller Index in Children. Pediatr Radiol. 2004;34(4):326-30. doi:10.1007/s00247-003-1116-1 - Pubmed

- Small bilateral chest incisions
- One thoracoscope incision
- Introducer passed posterior to the sternum and ribs, and anterior to the heart and lungs.
- Concave bar is slipped under the sternum, rotated anteriorly
- Secured with sutures and stabilizer



https://www.stanfordchildrens.org/en/service/chest-wall/pectus-excavatum

- Submammary incision
- Costal cartilage removed
- Sternum detached.
- A small bar is inserted underneath the sternum to hold it up in the desired position.
- The bar is left implanted until the cartilage grows back, usually 6 months.



www.stanfordhealthcare.org

Analgesic Plans

Regional

- Epidural
- Paravertebral
- Erector Spinae
- Cryoablation
- Wound soaker

Not Regional

- PCA
- Methadone?
- Multimodal analgesia

Studies: Retrospective Cohort

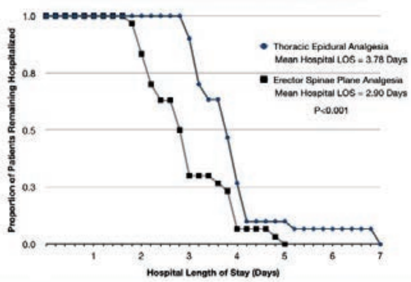
Average cumulative opioid use was significantly lower in the ESP block (67 mg) than the TE (117 mg) (p=0.0002) or the PCA group (172 mg) (p=0.0002).

The ESP block and PCA groups both had a significantly shorter average LOS (3.3 and 3.7 days, respectively) than the TE group (4.7 days).

ESP block performed best for reducing opioid consumption and LOS.

Santana L, Driggers J, Carvalho NF
Pain management for the Nuss procedure: comparison between erector spinae plane block, thoracic epidural, and control
World Journal of Pediatric Surgery 2022;5:e000418. doi: 10.1136/wjps-2022-000418

D.P. Bliss Jr., T.B. Strandness, S.C. Derderian et al. / Journal of Pediatric Surgery 57 (2022) 207–212



Kaplan-meier curve showing hospital length of stay for thoracic epidural analgesia patient group and erector spinae plane ana

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Analgesic Management for Pectus Excavatum Correction

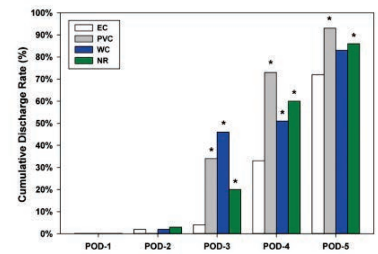

Figure 4. Cumulative discharge rate by POD for each analgesic strategy by POD for EC, PVC, WC, and NR. *Statistically significant versus epidural strategy based on the Wald test in logistic regression ($P < .05$). EC indicates epidural catheter; NR, no regional; POD, postoperative day; PVC, paravertebral catheter; WC, wound catheter.

Muhly, Wallis T. MD*; Beltran, Ralph J. MD†; Bielsky, Alan MD‡; Bryskin, Robert B. MD§; Chinn, Christopher MD‖; Choudhry, Dinesh K. MD¶; Cucchiaro, Giovanni MD#; Fernandez, Allison MD**; Glover, Chris D. MD††; Haile, Dawit T. MD‡‡; Kost-Byerly, Sabine MD§§; Schnepper, Gregory D. MD‖‖; Zurakowski, David MS, PhD¶¶; Agarwal, Rita MD##; Bhalla, Tarun MD†; Eisdorfer, Seth MD‡; Huang, Henry MD††; Maxwell, Lynne G. MD*; Thomas, James J. MD‡; Tjia, Imelda MD††; Wilder, Robert T. MD, PhD‡‡; Cravero, Joseph P. MD¶¶. Perioperative Management and In-Hospital Outcomes After Minimally Invasive Repair of Pectus Excavatum: A Multicenter Registry Report From the Society for Pediatric Anesthesia Improvement Network. Anesthesia & Analgesia 128(2):p 315-327, February 2019. | DOI: 10.1213/ANE.0000000000003829

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- Everyone has their favorite article to quote
- Whole team picks a technique, know it and get good at using it
- Teach to this technique- everyone on board a care pathway
- Always use multimodal analgesia
- Yes this includes opioids
- Thoracic epidurals keep you in a house longer but work
- PCA's give you more opioids but work
- ESP catheters, wound soakers, paravertebrals get you home quicker but a bit more owier

- Place it high
- Can use local and clonidine only
- Don't forget a muscle relaxant
- Teach pressure vs sharp pain
- Typically transition on day 3 which can be rough
- Order all the fixins
- Get that urinary catheter our early

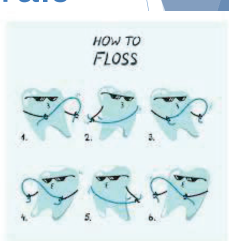
- Place it high
- Glue it in place
- We found no difference between 0.1% and 0.2% ropivacaine
- We run 0.2 % ropivacaine
- 0.1 ml/kg per side
- We give methadone 0.2 mg/kg up front
- Low dose muscle relaxants always

More Erector Spinae Tricks

- Bolus up front using 0.2% ropivacaine (0.1 ml/kg per side)
- Consider demand only PCA overnight
- We usually send home with elastomeric pump on day 2-3
- Followed daily at home until removed on POD 5

A word on paravertebrals

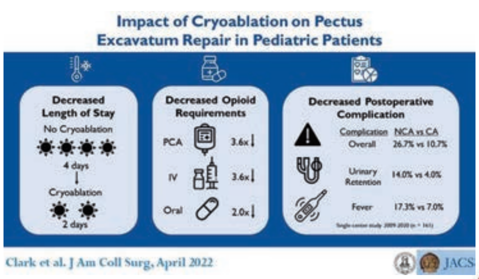
- Yes they work
- They seem hard to perform
- I have flossed a chest cavity with my surgical colleague
- I've also done intrapleural analgesia with this block
- Often requires bolusing
- Yes I consider them a deep block
- Yes they can go home

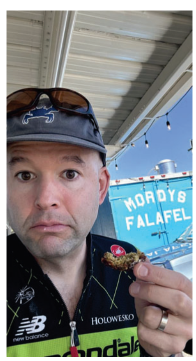


What about cryo-ablation

- Usually surgically performed
- Multiple levels needed
- Still needs an up-front analgesic plan
- No huge evidence of neuropathic pain outcomes
- Nerves grow back? 2-12 months?

Cryo..so far, so good





Study underway at Children's Hospital Colorado

- 3 Arm
- PCA
- Erector Spinae
- Cryoablation

Things we don’t do but seem…

Reasonable

- Wound soakers: need all the same stuff an ESP would
- Single shot block followed by multimodal opioid regimen
- Preoperative visit with pain psychology

Unreasonable

- Intraoperative acupuncture
- Opioid free anesthesia
- Jugs of oxycodone to go home with

Common Conundrums

- Preop- pain patients
- Extremes of Haller index
- Developmental disability
- Syndromes
- Backne
- The internet

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