ULTRASOUND-GUIDED PARAVERTEBRAL BLOCK

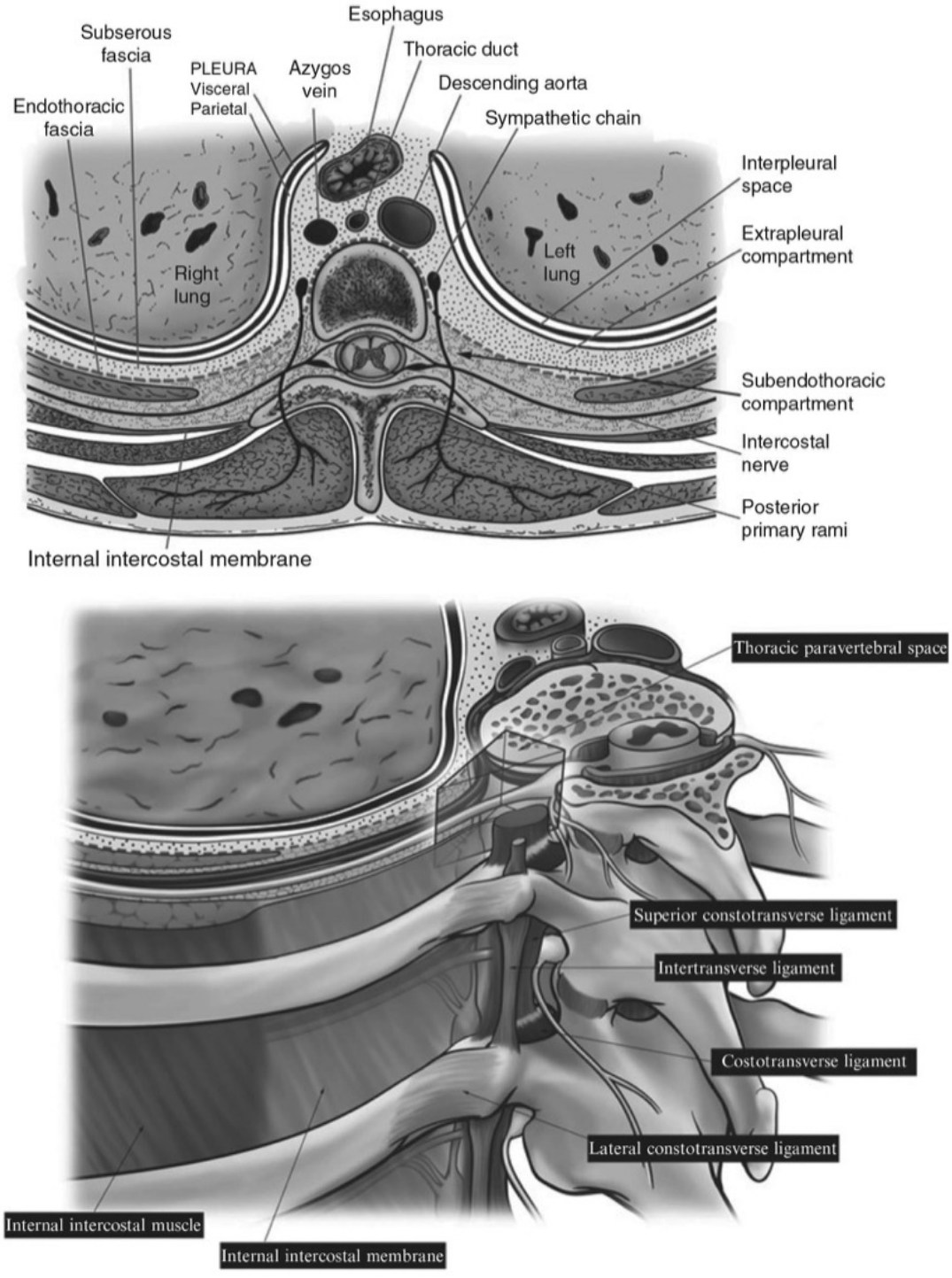
Surgical Specialty:	Regional Anesthesia
Authors:	Jenny Kan, MD, Smokey Clay, MD, Med Cincinnati Children's Hospital Medical Center: Cincinnati, OH

Background:

- **Indications:**
  - Paravertebral blocks/catheters are effective regional techniques for pain control during procedures in the truncal regions and non-operative pain treatment.
  - Examples of procedures where this may be indicated include:
    - Thoracotomy/thoracoscopy
    - Chest wall corrective surgery (e.g., Nuss procedure)
    - Sternotomy
    - Rib fractures
    - Breast surgery
    - Nephrectomy
    - Hernia repair
    - Major abdominal surgeries.[1-3]
  - Compared to alternative techniques (below), paravertebral blocks provide more complete coverage that resembles neuraxial blockade due to the proximity of paravertebral space to central neural structures.
    - Alternative techniques:
      - Thoracic epidural block
      - Erector spinae plane block,
      - Quadratus lumborum blocks
      - Multiple intercostal nerve blocks
      - Thoracic plane blocks.
  - Paravertebral blocks are good options for patients who have contraindications for epidurals, and they cause less motor weakness in the extremities when properly placed.

- **The Paravertebral Space:**
  - The thoracic paravertebral space is located on either side of the vertebral column. It is bordered by the parietal pleura anterolaterally, the superior costotransverse ligament posteriorly, and the vertebral body, intervertebral disk, and foramen medially.

- This space is filled with adipose tissue and contains the intercostal nerves (ventral rami of the T1-T12 nerves), the dorsal ramus, the rami communicantes, and the sympathetic chain (Fig. 1 & 2).[1]



Figures 1 & 2. The paravertebral space. Source: NYSORA[3]

- The thoracic spinal nerves are very sensitive to local anesthetics (LA) because they lie freely within the paravertebral space without epineurium and parts of the perineurium.[2]

- Literature using lumbar paravertebral blocks is limited in the pediatric population. Injections in the lower thoracic paravertebral space will cause a thoracolumbar paravertebral block.

- **Coverage/Distribution:**
  - A paravertebral block results in an ipsilateral sensory and sympathetic blockade at the dermatomal level of injection, as well as the spread of LA to several cephalad and caudad levels, depending on the volume of LA used. For example,0.25 mL/kg of contrast injected into the thoracic paravertebral space produces radiologic spread over a mean of 5.7 segments in pediatric patients.[4]
  - Visceral pain coverage is limited.

- **Patient Considerations**
  - Paravertebral blocks may be placed in children with a wide range of weights
    - Published literature describes paravertebral blocks in patients ranging from 6.25 to 135 kg and ages 6 months to 17 years.[5]
  - Contraindications[1-3]:
    - Patient/parent refusal
    - Infection at the injection site
    - Empyema
    - Allergy to local anesthetics
    - Neoplastic mass occupying the paravertebral space
    - Coagulopathy/therapeutic anticoagulation therapy (relative contraindication)
      - ASRA guidelines for deep peripheral blocks recommend
        - INR ≤ 1.4
        - Appropriately holding anticoagulant/antiplatelet medications before the procedure.
    - Kyphoscoliosis (relative contraindication)
      - Higher risk of pleural or dural puncture
    - Previous thoracotomy (relative contraindication):
      - Potential scar tissue in the paravertebral space
      - Adhesion of the lung to the chest wall makes it prone to pleural puncture

Anesthetic Planning:

- **Pre-Anesthetic Evaluation**
  - A focused history should include:
    - Coagulopathy/bleeding
    - Previous regional anesthesia experience
    - Previous surgeries (especially of the back, chest, and abdomen)
    - As this block is usually performed under general anesthesia in the pediatric population, consider the positional changes needed to perform the block (lateral decubitus, prone)
    - Medications (anticoagulants, antiplatelets, vasoactive drugs, anxiolytics/antidepressants, pain medications, dietary supplements, etc.)
    - Allergies
    - Physical examination should include cardiopulmonary, musculoskeletal (with a focus on the spine and block landmarks), skin (infection or lesion involving site(s) of injection), and neurologic exams.

- Additional labs/tests
  - Complete blood cell counts (CBC) and coagulation studies. Consider specific labs if the patient is on anticoagulants or antiplatelets.
- Discussions to have with the surgeon/family
  - Risks and benefits of the procedure.
  - Overall pain management plan. Set realistic goals and expectations.
  - When placing catheter(s) for continuous infusion, the provider should educate the patient about catheter care and the duration of therapy (up to five days).

- **Specific Room Set-Up Requirements**
  - Emergency airway supplies
  - Drugs/Infusions
    - Depending on the desired duration of analgesia, several LAs can be used. Table 1 summarizes suggestions based on published literature.
    - Systemic absorption of the LA solution administered is an important consideration, similar to an intercostal block. Using an epinephrine-containing solution is therefore recommended. Moreover, it reduces the hemodynamic effects of the ipsilateral sympathetic block.[6-7]
    - Lipid emulsion infusion set and vasopressors should be easily accessible.

Single shot:	
● 0.25% bupivacaine ● 0.2-0.5% ropivacaine	0.3-0.5 mL/kg per side (max 20 mL) 0.25-0.5 mL/kg per side (max 3 mg/kg)
Infusion (per side):	
● 0.125% - 0.25% Bupivacaine +/- epi ● 1% lidocaine +/- epi ● 0.1% - 0.2% ropivacaine	Infusion 0.2 mLkg/hr Infusion 0.25 mL/kg/hr Infusion 0.2-0.25 mL/kg/hr (max 12 mL/hr)
Adjunct medications:	
● clonidine ● fentanyl ● steroids ● ketamine	Limited evidence documenting the advantages vs. side effects. Further studies are needed.

Table 1. Medications used in paravertebral blocks/catheter infusions.[1-3,5]

- Blood Availability
  - Usually not required for the block but maybe for surgery (e.g., thoracotomy)
- PICU Bed Availability
  - Depending on the indication for the block (ex. thoracotomy)
- Other Indicated Resources
  - Ultrasound machine
  - Ultrasound probe
    - A linear 6-13 MHz probe is generally recommended; a curvilinear probe can sometimes be used for larger patients.
  - Needles

- Echogenic nerve block needles with length appropriate for the patient's size (40-50mm for small children, longer needles for older/obese patients)
- Catheter placement supplies when indicated. The authors' institution utilizes the Pajunk Echogenic Catheter-Over-Needle System.

Intraoperative Considerations:

- **General**
  - The use of general anesthesia to facilitate block placement is recommended.
  - Older patients may tolerate block placement under sedation and provide immediate feedback on block success. However, this is rarely done in pediatrics.

- **Positioning**
  - Lateral
    - Best for unilateral block/catheter.
    - The target side is up (for example, the patient will be in the left lateral decubitus position for right-sided blocks).
    - Shoulders can be rotated slightly and the bed can be tilted if more exposure to both sides of the back is desired.
    - Back slightly curved forward and legs flexed.
    - Pressure points padded. Axillary roll and pillows between the arms and legs if needed.
  - Prone
    - The prone position is best for bilateral blocks/catheters.
    - Pressure points padded.
      - Chest rolls and a prone pillow are needed.
    - Arms down by the side of the patient.
  - Sitting
    - Sitting is most comfortable when the patient is awake or under light sedation.
    - Ask the patient to sit on the side of the bed with their back curved out and lean slightly forward. An epidural chair may facilitate positioning.
  - Place the ultrasound screen on the opposite side, facing the proceduralist.

- **Techniques**
  - Perform a procedure time-out and confirm laterality.
  - Patients should be prepped and draped in a standard, sterile fashion to achieve maximal exposure of the targeted spine levels. Ultrasound cover and sterile gel should also be used.
  - **Step 1.** Locate and mark the spinous processes and targeted vertebral levels.
    - Landmark suggestions for determining the level of the injection(s):
      - T2-4 for breast surgeries
      - T4 for sternotomy
      - T6 for thoracotomy
      - T9-11 for abdominal procedures.

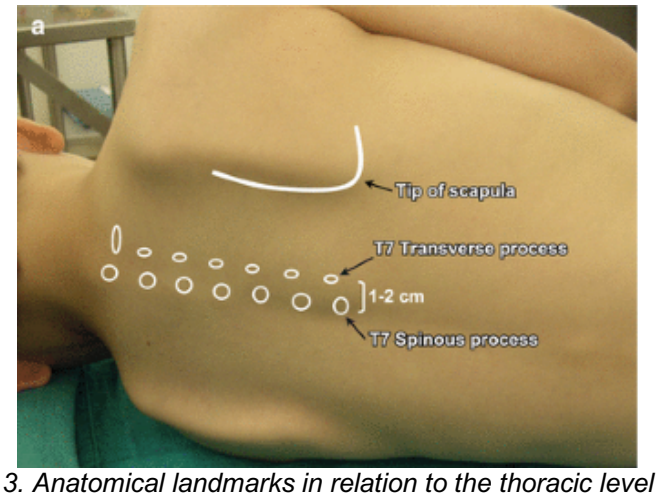


Figure 3. Anatomical landmarks in relation to the thoracic level transverse processes. Source: Pediatric Atlas of Ultrasound- and Nerve Stimulation-Guided Regional Anesthesia.[8]

- **Step 2.** Locate and mark the transverse process (TP), which is 1 - 2.5 cm lateral to the spinous process (Fig. 3). With the probe in the sagittal plane over the midline and sliding laterally, the lamina will first come into view, and the TP will be lateral to it. The pleura and the costotransverse ligament can be identified in this view (Fig. 4). Avoid scanning too laterally into the intercostal space.

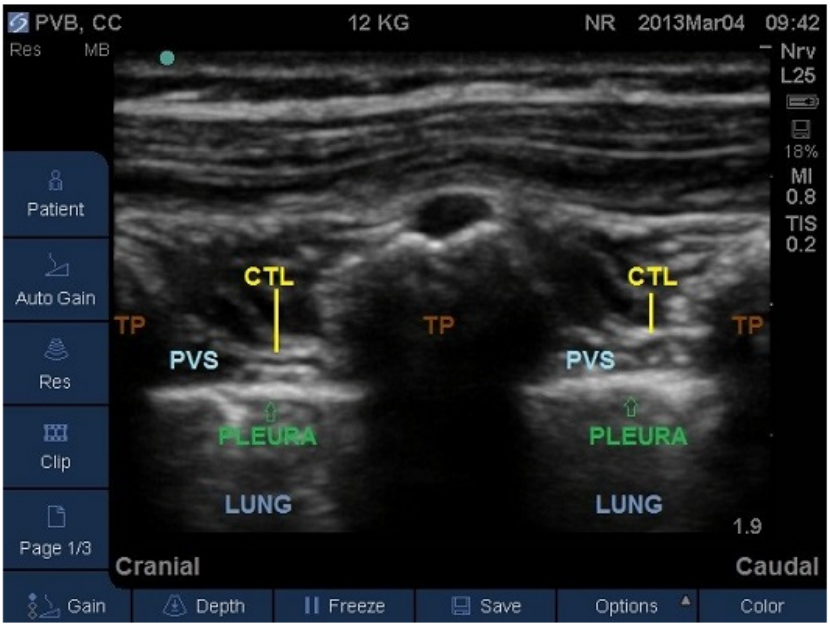


Figure 4. Parasagittal plane at mid-thoracic level. CTL - costotransverse ligament, PVS - paravertebral space, TP - transverse process. Source: European Society for Paediatric Anaesthesiology.[2]

- **Probe Sagittal, in-plane approach**
  - Adjust the probe as described in step 2, such that the TP of the targeted vertebral level is in the center of the screen.
  - Introduce the needle from the caudad end at an approximately 45-60° angle, aiming for the paravertebral space at the base of the targeted TP. Correct needle placement will result in downward displacement of the pleural with the

injection of a small amount of saline (Fig. 5). In older children, a loss of resistance may be felt after popping through the costotransverse ligament.

- If the aspiration test is negative, the desired amount of LA can be injected. Injection should be easy. If high resistance is felt, the needle may be against bony structures or in ligament and should be carefully moved under US guidance.

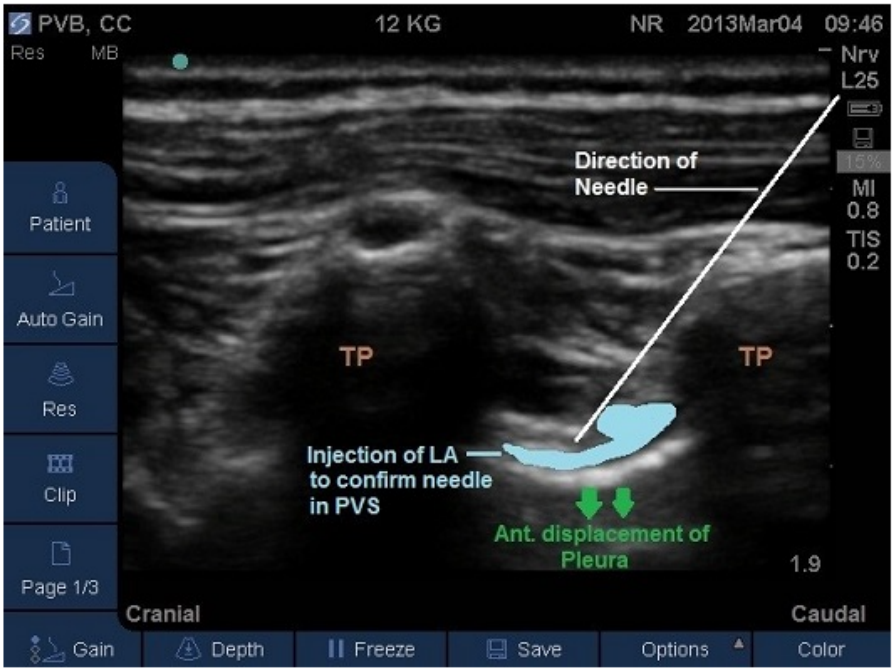


Figure 5. Correct paravertebral injection of local anesthetic with the parasagittal plane approach. Source: European Society for Paediatric Anaesthesiology.[2]

- **Probe <u>Transverse</u>, in-plane approach**
  - Place the ultrasound probe over the midline at the targeted vertebral level. Move the probe laterally to identify the lamina and the TP. The paravertebral space is lateral to the TP (Fig. 6).

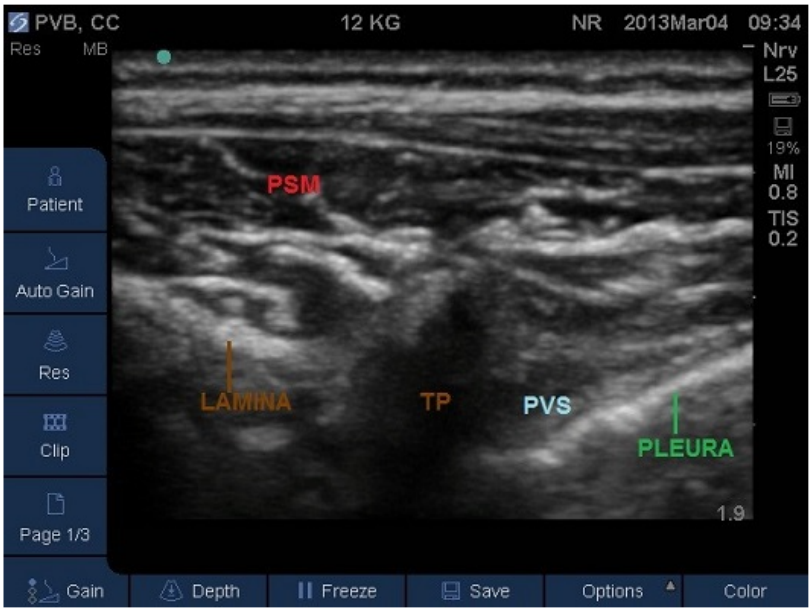


Figure 6. Transverse plane at mid-thoracic level. PSM - paraspinal muscles, PVS - paravertebral space, SP - spinous process, TP - transverse process. Source: European Society for Paediatric Anaesthesiology.[2]

- Introduce the needle from the lateral to the medial direction towards the junction of the pleura and the shadow underneath the TP (Fig. 7). Correct needle placement will result in downward displacement of the pleural with the injection of a small amount of saline and LA.

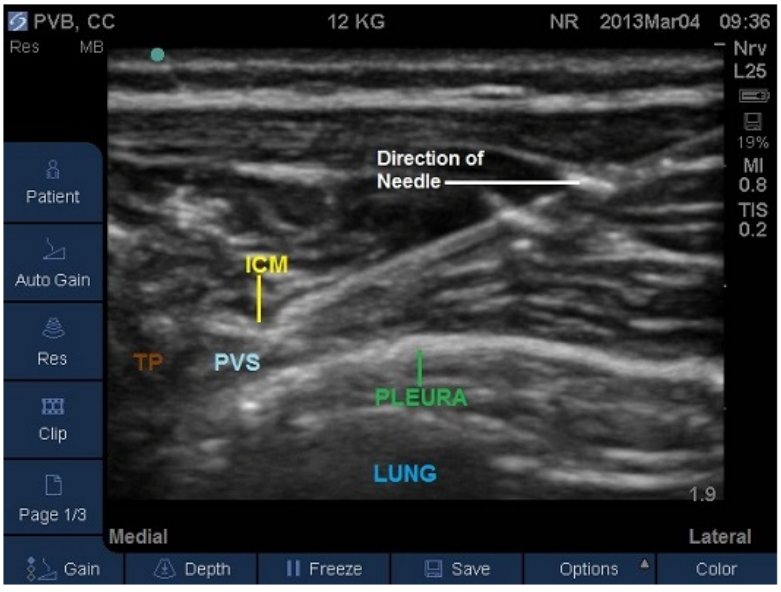


Figure 7. Correct paravertebral injection of local anesthetic with the transverse plane approach. ICM - internal intercostal membrane, PSM - paraspinal muscles, PVS - paravertebral space, TP - transverse process. Source: European Society for Paediatric Anaesthesiology.[2]

- Other out-of-plane approaches to paravertebral placement have been described.[2] However, an out-of-plane approach has an increased incidence of systemic symptoms from epidural spread due to the relation of need orientation to the axis of the neural foramen.

- **Hemodynamic/Physiologic Goals**
  - Age/clinical scenario-appropriate targets.
- **Surgical Considerations**
  - Communicate LA dosage with the surgical team. Ensure that the catheter(s) and dressing are away from the surgical field.
- **Post-procedural Care**
  - Monitor for side effects.
  - Evaluate for block efficacy (peak analgesia, duration, utilization of adjunct pain medications).
  - In the case of a high thoracic paravertebral blockade, a Harlequin or Horner syndrome may be observed due to an excessive sympathetic block: decreasing the infusion rate solves the problem.[9,10]
  - Follow the patient until block resolution or until catheter(s) is removed.

Case-Specific Complications/Pitfalls

Side effects:	**Management:**
Local anesthetic (LA) may spread laterally into the intercostal space or medially into the epidural space and to the contralateral side.[1] Inadvertent epidural or even intrathecal spread of LA may cause significant hemodynamic changes, respiratory depression, motor blockade, medication toxicity, and neurologic insults.	Ultrasound guidance decreases the chance of inappropriate needle placement and spread of the LA solution. Management depends on the clinical presentation. Epidural spread can be common, however, the amount of LA in the epidural space is often not large enough for clinically significant effects, especially for single blocks. Catheters should be removed or LA infusion should be adjusted for inadvertent epidural space placement. Intrathecal spread can be detrimental and can be more difficult to recognize in the pediatric population. Any signs of a “high/total spinal” should be identified promptly. Stop the procedure. Place the patient in the head-up position. Start supplemental oxygen, intubate if there are signs of respiratory failure, and administer IV fluids and vasopressors to support cardiac output and perfusion to vital organs.
Hypotension and bradycardia due to sympathectomy	Administer an IV fluid bolus with block placement. Emergency medications including vasopressors should be readily available to maintain hemodynamic stability.
Pneumothorax given the proximity to the pleura and patient pathology (e.g., rib fractures, kyphoscoliosis,	Start supplemental oxygen, obtain CXR, and surgical consult. An emergency exsufflation or, if necessary, a thoracostomy tube insertion plan should be in place.

previous thoracotomy with scar tissue formation)	Ultrasound-guided block placement decreases the chance of iatrogenic lung injury and increases the possibility of an early diagnosis of pneumothorax.
Local anesthetic systemic toxicity (LAST)	Administer an initial dose of 20% lipid emulsion at 1.5 mL/kg followed by an infusion at 0.25-0.5 mL/kg/min. Intralipid should always be accessible during and after the procedure and when a continuous catheter infusion is running. Signs and symptoms of early LAST should be monitored regularly.[11]
Bleeding	Check CBC/Coagulation studies. Administer reversal agents and/or transfusion if indicated. Screen for coagulopathies prior to block placement. Follow the ASRA guidelines for patients on antithrombotic or thrombolytic therapies. Paravertebral blocks are considered deep peripheral blocks.
Infection	Adherence to sterile techniques. Avoid performing the procedure on infected/compromised skin. In case of postprocedural fever or sepsis, antibiotic use and/or removal of catheter(s) if indicated.
Nerve injury	Monitor injection pressure; utilize patient feedback if the patient is awake. Expectant management if prolonged neuropathy develops as symptoms often self-resolve over time.
Block failure	For single blocks: Consider replacing block(s) at the vertebral level(s) of inadequate coverage with up to the maximum allowable LA dose. For catheters: Administer a bolus of LA and reassess for coverage. Maximize the rate of LA infusion if adequate coverage can be achieved after bolusing. Consider using more diluted LA to achieve a greater volume in the paravertebral space. Supplement with IV/PO/topical analgesic agents if needed.
Catheter-specific issues (e.g. leakage, dislodgement, reaction to dressing materials)	Catheter site(s) should be checked at least daily. Tighten catheter-tubing connections. A small amount of medication backflow at the skin is normal. The dressing should be changed if soaked, compromised, or causing a reaction. The catheter (s) may be replaced or removed if no longer in the proper position or functioning appropriately.

References

1. Davis PJ, Cladis FP. *Smith's Anesthesia for Infants and Children*. Elsevier Health Sciences; 2016.
2. Thoracic Paravertebral Block. European Society for Paediatric Anaesthesiology. Accessed November 4, 2022. Link
3. Ultrasound-Guided Thoracic Paravertebral Block. NYSORA. Published May 13, 2022. Link
4. Richardson J, Jones J, Atkinson R. The Effect of Thoracic Paravertebral Blockade on Intercostal Somatosensory Evoked Potentials. *Anesthesia & Analgesia*. 1998;87(2):373-376. PubMed Link
5. Boretsky K, Visoiu M, Bigeleisen P. Ultrasound-guided approach to the paravertebral space for catheter insertion in infants and children. *Pediatric Anesthesia*. 2013;23(12):1193-8. PubMed link
6. Karmakar MK, Ho AM, Law BK, Wong AS, Shafer SL, Gin T. Arterial and venous pharmacokinetics of ropivacaine with and without epinephrine after thoracic paravertebral block. Anesthesiology 2005;103:704-711. PubMed Link
7. Garuti I, Olmedilla L, Cruz P, Pineiro P, De la Gala F, Cirujano A. Comparison of the hemodynamic effects of a single 5 mg/kg dose of lidocaine with/without epinephrine for thoracic paravertebral block. Reg Anesth Pain Med 2008; 33: 57-63. PubMed Link
8. Ting HYZ, Boretsky KR, Tsui BCH. Paravertebral Blocks. In: *Pediatric Atlas of Ultrasound- and Nerve Stimulation-Guided Regional Anesthesia.* New York, NY: Springer; 2016:437-453.
9. Burlacu CL, Buggy DJ. Coexisting Harlequin and Horner syndromes after high thoracic paravertebral blockade. Br J Anaesth 2005; 95: 822-824. PubMed Link
10. Ludot H, Ponson FO, Belouadah M. Transient Horner's syndrome in an infant with continuous upper thoracic paravertebral blockade. Pediatr Anesth 2008; 18: 86-87. PubMed Link
11. Hernandez MA, Boretsky K. Chloroprocaine: local anesthetic systemic toxicity in a 9-month infant with paravertebral catheter. Pediatr Anesth 2016; 26: 665-666. PubMed Link

---

Reviewed by:

Reviewer #1: Ammar N. Yamani, M.D., FAAP, Texas Children's Hospital

Reviewer #2: Kevin Chu, M.D., Texas Children's Hospital

Reviewer #3: Francis Veyckemans, MD (Retired)

Senior Editor: Debnath Chatterjee, MD, FAAP, Children's Hospital Colorado

---

Created: 10/24/2022; Last revised: 08/27/2024