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PEDIATRIC
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Evidence-Based Education • Practical Application

CLINICAL CHALLENGES

- What are common physical examination findings in pediatric patients with pleural space pathologies?
- Which diagnostic imaging studies are considered first-line modalities for assessing pleural space pathologies?
- Which anatomic sites are recommended for needle decompression and chest tube placement?
- What are the criteria for performing a thoracotomy in the emergency department?

Thoracostomy and Thoracotomy for Emergency Management of Pediatric Pleural Space Pathologies

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Prior to beginning this activity, see the "CME Information" on page 2.

Abstract

While indications and techniques for thoracostomy are well-studied in adults, pediatric-specific evidence remains limited for emergency department-based thoracostomy and especially thoracotomy. The ability to perform urgent interventions for life-threatening pleural space pathologies is essential for all emergency clinicians. This issue reviews the clinical indications for thoracostomy and thoracotomy in pediatric patients, outlines procedural considerations for these techniques, and discusses potential complications in the emergency department. Advancements in the field are also highlighted, including emerging approaches to reduce procedural delays and improve patient outcomes.

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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) identify areas in practice that require modification to be consistent with current evidence in order to improve competence and performance; (2) develop strategies to accurately diagnose and treat both common and critical ED presentations; and (3) demonstrate informed medical decision-making based on the strongest clinical evidence.

CME Objectives: Upon completion of this activity, you should be able to: (1) differentiate between common causes of pediatric pleural space disease, based on patient history, physical examination, and clinical presentation; (2) identify appropriate indications for needle decompression, large-bore chest tube, and pigtail catheter; and (3) apply evidence-based approaches to manage pediatric patients with pleural space disease, including strategies for pain control and postprocedural monitoring.

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Case Presentations

CASE 1

A 16-year-old boy is brought in via EMS after an all-terrain vehicle accident…

- The boy was riding without a helmet when he lost control of his vehicle and hit a tree. He did not lose consciousness, but his chest hit the steering wheel. He has right-sided rib pain and shortness of breath.
- On examination, he has right upper quadrant abdominal tenderness, diaphoresis, tachycardia, and tachypnea, with an oxygen saturation of 93% on room air.
- You order a chest x-ray and begin to think about what interventions are needed…

CASE 2

A 16-year-old boy with increased work of breathing arrives via transfer from a different hospital…

- The boy says he does not have an underlying cardiac or pulmonary history, and he has not been ill or had a fever recently.
- His vital signs are stable. A chest x-ray from the referring hospital shows a moderately sized pneumothorax.
- The pediatric surgical team is unable to come to the ED because they are scrubbed in on a surgical case. They ask if you could place a pigtail catheter if a repeat chest x-ray shows a pneumothorax of equal or larger size.
- You try to remember the best location for insertion of a pigtail in this age group…

CASE 3

A 4-year-old girl who was involved in a shooting arrives to your community hospital…

- The girl has a gunshot wound to her right torso. She is hemodynamically unstable, with respiratory distress and a respiratory rate in the 50s.
- You activate the massive transfusion protocol and call the blood bank to have packed red blood cells on standby.
- Your community hospital lacks the resources to definitively manage this patient, so you consider what stabilization is required prior to transfer…

Introduction

The treatment of pleural space disease in children depends on the etiology, injury severity and type, available resources, and access to subspecialists. Interventions include needle aspiration, tube thoracostomy, and thoracotomy. Thoracostomy procedures drain fluid, air, or purulent material from the pleural space to allow the lung to re-expand.[1] Fluids found in this space can include transudative or exudative pleural effusions, chyle, and blood.[2] Lymphatic fluid can also accumulate in the pleural space following disruption of the thoracic duct (chylothorax), although this is a rare condition in pediatric patients. This may occur after surgery or may be due to nontraumatic causes (eg, malignancy and/or lymphatic obstruction).[1,3] Air in the pleural space, or pneumothorax, is a potentially life-threatening condition requiring timely intervention. Diagnosing and treating pleural space disease in children is a critical skill for emergency clinicians.

This issue of *Pediatric Emergency Medicine Practice* provides a review of thoracostomy and emergency resuscitative thoracotomy in pediatric patients. These procedural interventions are often co-managed with trauma surgeons or pediatric surgeons. Although many emergency clinicians will never encounter an indication for an emergency resuscitative thoracotomy in a pediatric patient and are unlikely to perform the procedure independently, it is important to review its indications, as well as the associated risks and benefits.

Critical Appraisal of the Literature

A literature search was performed in PubMed, using single search terms and combinations of the following terms: *pediatric*, *children*, *pneumothorax*, *pleural effusion*, *empyema*, *hemothorax*, *needle decompression*, *pigtail*, *thoracotomy*, *chest tube*, *thoracostomy*, *chest CT*, *ultrasound*, *thorax*, and *CXR*. More recent works were prioritized, and article titles and abstracts were filtered for relevance. Article bibliographies were also reviewed for relevant publications. The Advanced Trauma Life Support® (ATLS®) updates, which provide the current recommendations for chest tube placement in pediatric patients, were also included.[4]

Etiology and Pathophysiology

The pleural space is a thin cavity between a visceral (lung surface) and parietal (inner chest wall) pleural layer.[2] The pleural space contains a small amount of fluid, determined by the balance of hydrostatic and oncotic pressures. This fluid enables the pleural layers to move smoothly against each other within the chest cavity during breathing.[2,5] However, when excess air (pneumothorax) or fluid (hemothorax, effusion) accumulates in this space, lung expansion is impaired.

Pneumothorax

A pneumothorax can be primary (found in an individual without underlying lung disease) or secondary (associated with an underlying lung disease).[2] The incidence of spontaneous pneumothorax in children aged <18 years increased from 2.7 per 100,000 in 1997 to 3.4 per 100,000 in 2006, with the average age being 15 years.[6] Among children in the United States, unintentional injuries are the leading cause of morbidity and mortality, with most of these injuries resulting from blunt trauma that can result in significant pleural space pathology.[7] Tension pneumothorax is a severe, life-threatening condition in which air is drawn into the pleural space during inhalation and accumulates. This can lead to progressively rising intrathoracic pressure and subsequent compression of surrounding thoracic structures, as evidenced by tracheal deviation and ipsilateral lung collapse.[8,9]

Pleural Effusions

Pleural effusions are classified as either transudative or exudative. Transudative effusions result from an imbalance between hydrostatic and oncotic pressures, whereas exudative effusions occur due to pleural inflammation, which disrupts the endothelial barrier, increases vascular permeability, and allows proteins and plasma to leak into the pleural space.[2] A parapneumonic effusion is a type of exudative pleural effusion that is associated with lung infection. An empyema is an accumulation of grossly purulent fluid in the pleural cavity that develops from an adjacent pneumonia.

Effects of Impaired Gas Exchange

The presence of air or fluid in the pleural space can lead to lower lung volumes, which promotes alveolar collapse and ventilation-perfusion mismatch and results in intrapulmonary shunting.[10] This impaired gas exchange and oxygenation yields the clinical manifestations of respiratory distress or failure, such as tachypnea, hypoxemia, and signs of increased work of breathing. Chest pain and cough may also occur, depending on the etiology of pleural pathology.

Differential Diagnosis

The differential diagnosis for pleural space pathology in pediatric patients is broad and includes spontaneous, traumatic, inflammatory, infectious, and iatrogenic causes. The clinical presentation, patient history, physical examination, and imaging studies are critical in differentiating between these conditions.

Pneumothorax

The mechanisms of pneumothorax illustrate the diversity of pediatric pleural space pathologies, ranging from air accumulation due to underlying lung abnormalities to trauma-related injuries. In primary spontaneous pneumothorax, subpleural air cysts or blebs in the lung apices can be found. One study showed that almost 40% of pediatric patients with spontaneous pneumothorax were subsequently found to have air cysts on chest computed tomography (CT).[11] For secondary spontaneous pneumothorax, examples of underlying lung pathology include interstitial lung disease and connective tissue diseases such as Marfan syndrome and Ehlers-Danlos syndrome (likely due to structural abnormalities such as cysts in the lung parenchyma).[11] Neonatal pneumothorax can be associated with transient tachypnea of the newborn and respiratory distress syndrome. A retrospective cohort study that reviewed 71 cases of neonatal pneumothorax found that almost all of the patients had underlying lung disease.[12] Pneumothorax secondary to trauma is often caused by blunt chest trauma, including falls, motor vehicle crashes, and sports injuries.[13] When rib fractures are present in pediatric trauma patients, they are often accompanied by injuries involving the brain, spleen, or liver.[14] However, rib fractures are uncommon, occurring in <3% of pediatric trauma patients, according to National Trauma Data Bank analysis.[14,15]

Pleural Effusions

Transudative effusions may result from conditions that cause fluid overload such as heart failure, while exudative pulmonary effusions may result from trauma, infection, inflammation, or malignancy.[2]

Prehospital Care

Prehospital care for patients with suspected pleural space pathology focuses on stabilization and preparation for rapid transport to the ED. Initial assessment begins with the primary survey to identify life-threatening concerns.[4] Intubation may be necessary for airway compromise or in the setting of respiratory failure.[4,16] If there is concern for tension pneumothorax in a patient who is not apneic, needle decompression should be performed immediately, prior to intubation, to avoid a worsening tension pneumothorax. For a chest trauma patient with a Glasgow Coma Scale score <8, airway protection with endotracheal intubation is generally indicated.[16] Management of breathing and circulation may include the administration of high-flow oxygen and the establishment of intravenous (IV) or intraosseous access.[4] In conjunction with the primary survey, vital signs and the history of the injury can provide important information necessary for patient evaluation and treatment.

Decompression

Tension pneumothorax is a clinical diagnosis, based on signs such as severe respiratory distress, hypotension, unilateral absent lung sounds, and tracheal deviation toward the contralateral lung. This diagnosis should prompt immediate intervention with needle thoracostomy, which is the first-line treatment. A needle thoracostomy is an emergency procedure in which a large-bore needle is inserted into the pleural space to rapidly relieve intrathoracic pressure from a tension pneumothorax before definitive chest tube placement.[4] Although needle thoracostomy is the most common emergency medical services (EMS) treatment for tension pneumothorax, prehospital decompression success rates remain low, due to technical challenges, equipment limitations, and diagnostic uncertainty.[17] Finger thoracostomy is an emergent chest decompression technique in which a scalpel incision is made at the fifth intercostal space, and a finger is inserted to release air or fluid.[4,12] Standard protocol dictates that a chest tube should be placed in the ED after needle or finger decompression for tension or large pneumothorax and hemothorax.

Pain Management

Pain management is a key component of prehospital care, since adequate analgesia can improve patient comfort, oxygenation, and respiratory effort. Clinician anxiety regarding caring for pediatric patients and concerns about the adverse effects of analgesics are barriers to effective pain management in the prehospital setting, often leaving patients undertreated.

Transport Considerations

Considerations regarding transport, whether by ground, ambulance, or air, are an important component of prehospital care. The decision of whether to perform tube thoracostomy or needle decompression prior to transport depends on the severity of the patient's clinical status and available resources.[18] Additionally, transporting patients with an untreated pneumothorax by air is contraindicated, as the lower pressure at higher altitudes can cause gas expansion, potentially enlarging a pneumothorax, creating a tension pneumothorax, or exacerbating respiratory compromise.[4,12,19] According to the 2025 ATLS® guidelines, tube thoracostomy should be performed prior to air transfer, especially if the transfer team is not equipped to perform emergent chest decompression. Transportation decisions should also factor in regional protocols and field triage guidelines.[4,18]

Emergency Department Evaluation

Evaluation of a patient with suspected pleural space disease in the ED begins with a thorough history and physical examination to identify potential underlying causes. To get a complete clinical picture, it is essential to obtain a thorough past medical history and a history of the events leading up to ED presentation. When conducting the physical examination of a pediatric patient with pleural space disease, it is important to begin with the primary survey and to use vital signs to obtain adequate information to stabilize the patient. A pneumothorax will present with hyperresonance on percussion on the affected side.[20] A patient with a pleural effusion may have tachypnea, tachycardia, diminished breath sounds, dullness to percussion, transmitted speech, and egophony on the affected hemithorax.[20] Patients with parapneumonic effusions typically present with prolonged fever, chest and abdominal tenderness, and tachypnea.[21] **See Table 1** for a list of possible physical examination findings in patients with pleural space pathologies.

Diagnostic Studies

Chest X-Ray

Chest x-ray is the first-line imaging modality for evaluating pleural space pathology, due to its rapid availability, lower radiation exposure compared to other imaging modalities, and ability to detect key abnormalities. There are few studies available on the efficiency of chest x-ray in penetrating trauma to the chest in children. ATLS® guidelines recommend using chest x-ray as the initial imaging modality, even though its sensitivity for detecting thoracic injuries in pediatric patients is relatively low.[4]

On chest x-ray, a pneumothorax appears as a thin, sharply defined visceral pleural line with no lung markings beyond it. **(See Figure 1, page 6.)** This finding, which indicates air in the pleural space, is most easily seen on an expiratory film.[22] When x-ray is performed in the supine position, a pneumothorax may appear anteriorly and medially, creating a deep sulcus sign, which appears as a deep costophrenic angle or double-diaphragm sign.[23,24] **(See Figure 2, page 6.)**

Table 1. Possible Physical Examination Findings in Patients With a Pleural Space Pathology

- Abdominal tenderness (especially upper quadrants)
- Altered mental status
- Cyanosis
- Diminished breath sounds
- Dyspnea
- Neck vein distension
- Palpable crepitus/subcutaneous emphysema
- Signs of chest wall injury
- Signs of hemodynamic instability (tachycardia, hypotension)
- Signs of increased work of breathing (retractions, nasal flaring)
- Tachypnea
- Thoracic wall tenderness
- Tracheal deviation towards the contralateral side
- Unilateral absence of breath sounds

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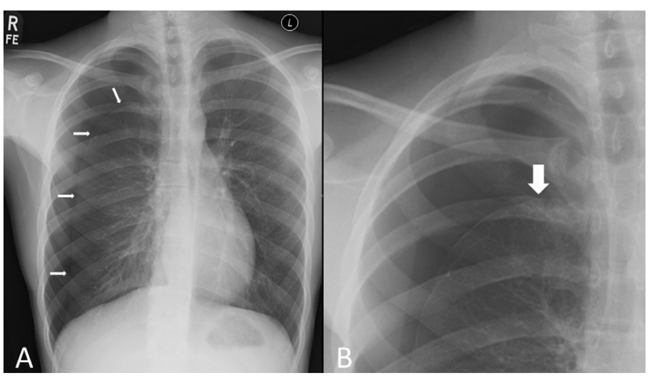
The American Association for Thoracic Surgery recommends chest x-ray as the initial step in the investigation of pleural space disease.[25] If ≥175 mL of pleural fluid is present, blunting of the costophrenic angle can be seen on posteroanterior film **(see Figure 3)**, with smaller effusions found on lateral view.[25] Chest x-ray has some limitations, and small, loculated effusions may be difficult to visualize, often due to being obscured by an additional finding of lower lobe consolidation. Thus, supplementation with ultrasound or CT can be helpful.[25]

Ultrasound

Ultrasound is being used with increasing frequency because it is fast, inexpensive, and nonionizing. It also offers the advantage of detecting subtle findings that may be missed on chest x-ray.[26] The American Association for Thoracic Surgery emphasizes the value of ultrasound in identifying even small pleural effusions, estimating their volume, and distinguishing between simple and complex effusions with or without septations. In the emergency setting, ultrasound often performs better than chest x-ray.[25]

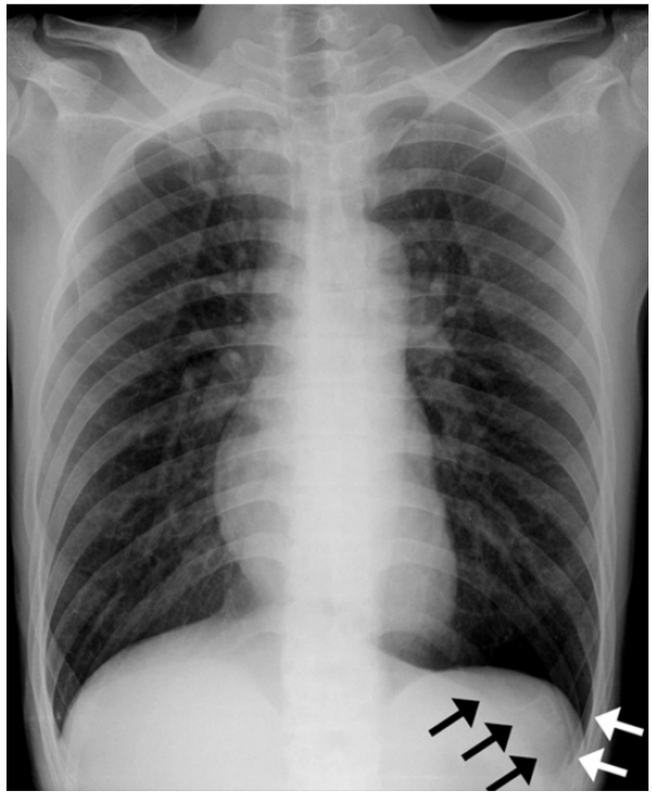
A lung ultrasound is typically performed using a linear probe. A normal lung on thoracic ultrasound in a healthy individual will contain unique patterns, including A-lines, a pleural line, lung sliding, and ribs with rib shadow. Lung sliding can also be visualized using M-mode (motion-mode), in which the image is described as a "seashore sign," because it resembles waves on a beach. **(See Figure 4, page 7.)** When a pneumothorax is present, ultrasound will show an absence of lung sliding. This is seen in M-mode as a "barcode sign" or "stratosphere sign."[27] The lung

Figure 1. Spontaneous Pneumothorax on X-Ray



A: A large right-sided pneumothorax with a visible lung edge (thin arrows), lack of lung markings beyond this demarcation and mediastinal shift.
B: A magnified view illustrates a cluster of tiny subpleural blebs at the right lung apex (thick arrow).
Reproduced from: Fifteen-minute consultation: a structured approach to a child with primary spontaneous pneumothorax. *Archives of Disease in Childhood: Education & Practice*, Simon James Buckley, John Adu, Donald Whitaker, Atul Gupta. Volume 107, Pages 320-325. © 2022 with permission from BMJ Publishing Group Ltd.

Figure 2. Deep Sulcus Sign on X-Ray



Supine chest radiograph showing an abnormal deepened left lateral costophrenic angle with increased lucency (arrows), indicating a left pneumothorax with a "deep sulcus sign."
Reproduced from: Deep sulcus sign. *Emergency Medicine Journal*, Yao-Hui Tseng, Kao-Lang Liu, I-Lun Shih. Volume 29, Page 608. © 2012 with permission from BMJ Publishing Group Ltd.

Figure 3. Pleural Effusion on X-Ray

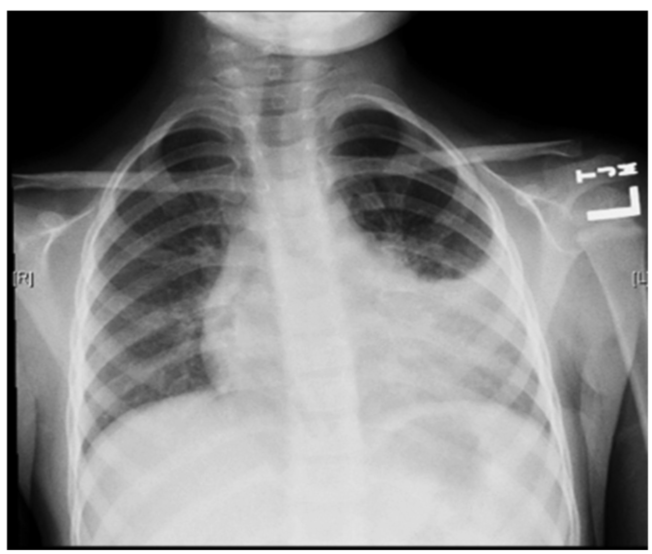


Image courtesy of James Naprawa, MD.

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point, which is the interface between active pleural sliding and the absence of motion in a pneumothorax, can also be seen on ultrasound. **(See Figure 5.)**

For more information on the appearance of a normal lung on ultrasound, see the November 2015 issue of *Pediatric Emergency Medicine Practice* titled, "Pediatric Chest Tubes and Pigtails: an Evidence-Based Approach to the Management of Pleural Space Diseases," available at www.ebmedicine.net/pediatric-chest-tubes

For a review of findings suggestive of a pneumothorax, see the March 2017 issue of *Pediatric Emergency Medicine Practice* titled, "Pneumothorax in Pediatric Patients: Management Strategies to Improve Patient Outcomes," available at www.ebmedicine.net/pediatric-pneumothorax

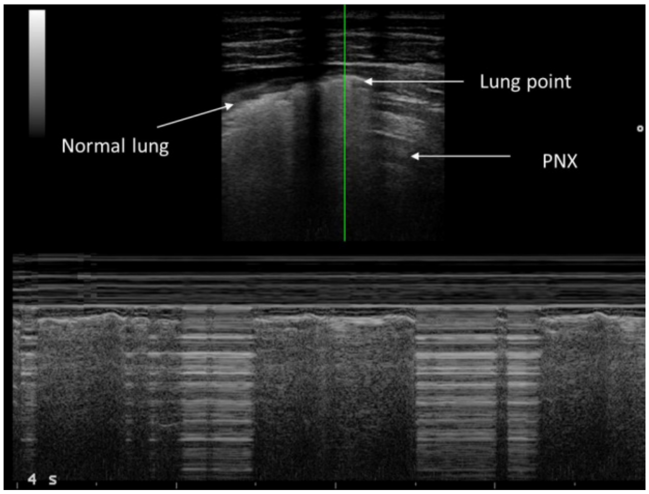
Computed Tomography

Routine use of CT for children with pleural space pathology is not generally recommended, due to the high levels of ionizing radiation and limited evidence showing changes in clinical management or improved outcomes.[28] When evaluating pleural space disease in children, CT is predominantly used when further evaluation of a complex pleural effusion is needed or when there is strong clinical suspicion for an effusion, bronchopleural fistula, mass (eg, lymphoma), or necrotizing pneumonia.[29]

On CT, pneumothorax appears as an area devoid of lung markings, with the lung margin separate from the chest wall. Apical cysts or blebs may also be found after primary spontaneous pneumothorax.[11]

Pleural effusions appear as areas of increased attenuation, and may be classified as simple or complex, with features such as loculations or septations. However, attenuation values alone are often unreliable for accurate characterization.[30]

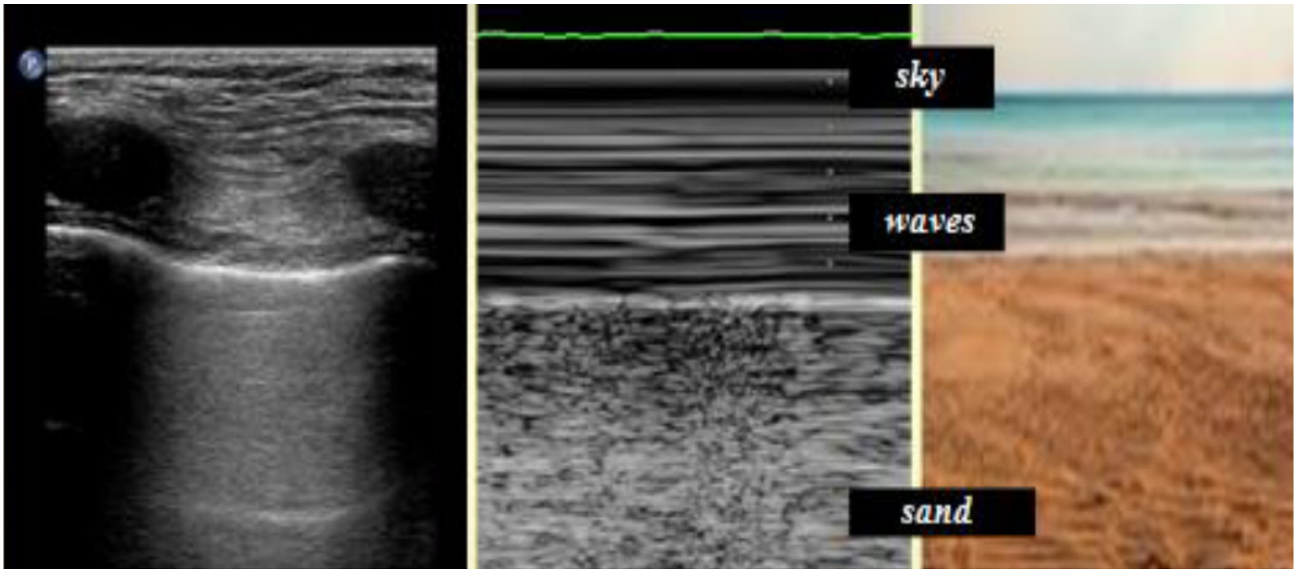
Figure 5. The "Barcode Sign" on M-Mode Ultrasound



Abbreviation: PNX, pneumothorax.

Barbara Scialanga, Danilo Buonsenso, Simona Scateni, et al. Lung ultrasound to detect pneumothorax in children evaluated for acute chest pain in the emergency department: an observational pilot study. *Frontiers in Pediatrics*. Volume 10 – 2022. © 2022 Scialanga, Buonsenso, Scateni, Valentini, Schingo, Boccuzzi, Mesturino, Ferro, Chiaretti, Villani, Supino and Musolino. https://doi.org/10.3389/fped.2022.812246 Used under the Creative Commons Attribution License (CC BY 4.0)

Figure 4. Seashore Sign on M-Mode Ultrasound



Above the pleura, the scan reveals wave-like lines, generated by the movement of muscles (waves) and the skin (sky). Underneath the pleura, the image shows a grainy pattern resembling the sand, which is the result of lung sliding.

Anđelka Ristić-Anđelkov, Zorica Mladenović, Branislav Baškot. The role of lung transthoracic ultrasound in clinical practice. *Vojnosanitetski Pregled*. Volume 73, Issue 8. Pages 770-773. Copyright 2016 Military Health Department of the Ministry of Defense of the Republic of Serbia. https://doi.org/10.2298/VSP150607084R Used under a Creative Commons Attribution 4.0 International License (BY-SA 4.0)

Treatment

Preprocedural Preparation

Preprocedural consent may be considered in non-emergent contexts. Procedural landmarks, antiseptic preparations, analgesia, anxiolysis, and sedation may also be considered during this time. **(See Table 2.)**

Pain Management

The American Society of Anesthesiologists emphasizes a multimodal approach to pediatric analgesia and anxiolysis, suggesting that combining medications prior to procedures may be optimal.[32] Although the literature varies regarding ideal sedation and analgesic agents and dosages, there is a consistent emphasis on individualized pain management. The American College of Emergency Physicians similarly emphasizes the need for prompt, safe, and effective acute pain management in the ED.[33] Nonpharmacologic measures (eg, ice/heat, repositioning, topical sprays, relaxation techniques) should be considered first. When analgesic medications are needed, consider initiating treatment with nonopioid medications (eg, nonsteroidal anti-inflammatory drugs or acetaminophen) when possible. Regional analgesia (eg, nerve blocks or local/IV lidocaine) should also be considered and performed under ultrasound guidance if feasible.[34] For preprocedural or more severe pain, ketamine may be used alone or as part of a multimodal strategy. Opioids should be reserved for severe or refractory pain; fentanyl is a useful option in these cases, given its ease of dosing and multiple routes of administration (IV, intramuscular, intranasal).

Supportive Care

In the setting of a small pneumothorax in a clinically stable child, supportive care, including observation, rest, analgesia, and supplemental oxygen, may be adequate.[35,36] Oxygen therapy has traditionally been thought to increase the speed of spontaneous pneumothorax resolution via the nitrogen wash-out theory, in which oxygen lowers blood nitrogen levels, increasing the gradient for air absorption from the pleural space, but much of this data is from adult and animal model studies.[37] Oxygen therapy may be ineffective for larger pneumothoraces, but it has little risk and is often administered prior to chest tube placement. Supplemental oxygen has not been found to resolve empyemas. Clinically stable pediatric patients with small empyema, no mediastinal shift on chest x-ray, and without respiratory distress should be treated with IV antibiotics. Small effusions do not require chest tube placement. Even for moderate/large effusions, antibiotics without chest tube placement may be sufficient in the absence of respiratory distress and/or cardiovascular compromise.[38]

Table 2. Preprocedural Preparation Checklist[31]

- Adequate equipment for specific procedure
  - Drainage assembly and functional suction
  - Pigtail catheter kit
  - Tube thoracostomy kit
- Adequate preprocedural imaging if needed
- Analgesia (eg, local lidocaine, intravenous pain medication)
- Monitoring and preparation for an advanced airway
- Personal protective equipment (eg, gloves/sterile gloves, mask, gown, eye protection, shoe coverings)
- Gauze, tape
- Procedural consent
- Scalpel, forceps
- Sedation consent
- Site selection/labeling with skin marker
- Sterile preparation solution
- Sterile towels, drapes/dressings
- Suture kit/laceration tray

Thoracostomy

Needle Thoracostomy

Needle thoracostomy is a procedure used for emergency management of tension pneumothorax and should be performed prior to chest tube placement. According to the 2025 edition of ATLS®, physiology and management are similar in adults and children.[4] To prepare for a needle thoracostomy, identify landmarks for insertion and properly clean the insertion site. ATLS® specifies the need for a large-bore (eg, 14-gauge) over-the-needle catheter to be placed in either the second intercostal space at the midclavicular line, or in the fourth or fifth intercostal space just anterior to the midaxillary line.[4] Although the second intercostal space is familiar to most clinicians and is a reasonable approach for small children, the fifth intercostal space warrants particular consideration. Evidence suggests it may be thinner than the second intercostal space, although there is heterogeneity in study results.[39-41] **See Figure 6, page 9** for needle thoracostomy sites.

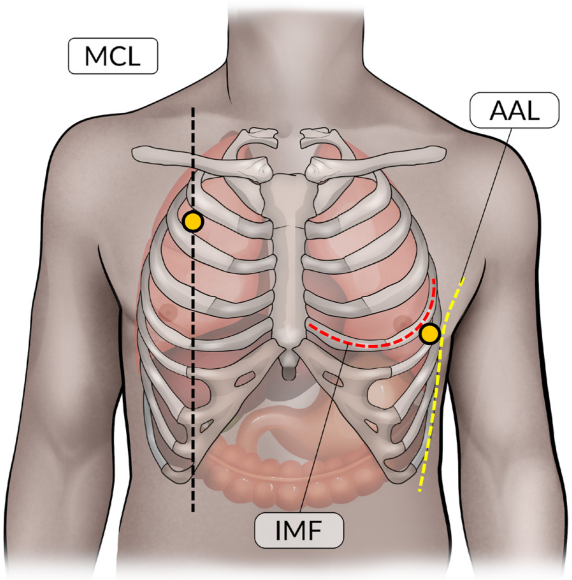
An appropriately sized needle is important. If the needle is not the correct size for the chest wall thickness, needle decompression may fail due to catheter kinking or cause damage to intercostal vessels or intrathoracic structures.[42] ATLS® recommends a 2.5- to 4.5-cm/16- to 22-gauge needle for children, based on the child's age and body habitus.[4] **See Table 3, page 9** for needle size recommendations based on age.[43] For adult-sized patients, the literature suggests that the needle should be at least 8 cm in length. A 5-cm over-the-needle catheter reaches the pleural space in >50% of cases, compared with >90% for an 8-cm catheter.[4,44,45]

While signs of procedural success are variable, they include improvement in breath sounds and oxygen saturation, as well as a possible "gush of air," though this finding is subjective, temporary, and inconsistent.[46,47] Objective improvement of vital signs, including resolution of hypoxia and hypotension, is a more reliable indication of successful needle decompression.[48] If successful, the tension pneumothorax will be converted to a simple pneumothorax, so tube thoracostomy and definitive management must follow.

Chest Tube Thoracostomy

Chest tube thoracostomy is the definitive treatment for any pneumothorax and should be performed after needle decompression. It is also utilized for other pleural space pathologies, such as empyema. Prior to beginning the procedure, properly position the patient supine, with the ipsilateral arm abducted and externally rotated, with the palm of the hand behind the head, to optimize intercostal space size.[49] Sterilize the area, and administer local lidocaine to the insertion site. Insertion length can be estimated by placing the tip of the chest tube near the clavicle and extending it towards the incision site.[4] Place the tube in the midaxillary line in the fourth or fifth intercostal space just above the rib to avoid the neurovascular bundle.[50,51] The tube should be placed posteriorly or superiorly for air drainage and inferiorly for fluid drainage. After tube placement, secure the tube using sutures and connect to a drainage system. Obtain a chest x-ray to assess for tube placement and residual pneumothorax size.

Figure 6. Needle Thoracostomy Locations



Two anatomically preferred sites for needle decompression are marked. This includes an anterior approach in the second intercostal space along the midclavicular line (MCL) and a lateral approach just posterior to the anterior axillary line (AAL) at that level of the inframammary fold (IMF).

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Table 3. Recommended Needle Sizes[4,43]

Patient Category	Approximate Age/Habitus	Recommended Needle Length (cm)	Recommended Needle Size (G)
Infant/small child	<5 years	2.5-3.2	20-22
Young child	5-10 years	3.2-4.5	18-20
Older child/ adolescent	>10 years	4.5-8	16-18
Adult-sized individual	Adult habitus	≥8	14-16

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Pigtail Catheter Thoracostomy

Pigtail catheters can be placed for a variety of pathologies, including pneumothorax, pleural effusion, and ascites or abscess drainage. Using the Seldinger technique, a guidewire is passed through the needle and a dilator is used for tract enlargement, then the catheter is placed over the guidewire. Some complications of catheter placement include failure to drain, dislodgment, and kinking of the catheter, with more complications observed in children weighing <5 kg than in larger children.[4,52] A retrospective study showed that complications were uncommon with placement of pigtail catheters in pediatric patients, with hemothorax or pneumothorax occurring in approximately 2% of cases.[52] Care should be taken when considering a chest tube versus pigtail catheter for empyema; ideally, this decision should be left to the surgical team.

Overall, pigtail catheter thoracostomy has been shown to be safe and effective. A retrospective, multicenter cohort study across >40 trauma centers found no significant differences in treatment failure, hospital length of stay, or discharge disposition in hemodynamically stable pediatric patients treated with small-bore pigtail catheters or traditional large-bore chest tubes for traumatic hemothorax or hemopneumothorax.[53] For cases of spontaneous pneumothorax, pigtail drainage has been associated with lower complication rates, shorter drainage durations, and shorter hospital stays.[53] Pigtail catheters for spontaneous pneumothorax have been shown to be less painful than chest tubes due to their smaller size, a smaller incision, and less tissue disruption.[8] In a retrospective pediatric study, children with pigtail catheters were found to require less opioid pain medication at the time of insertion and on subsequent assessments.[54]

Thoracotomy

In rare cases of trauma-related cardiac arrest, thoracotomy may be required, particularly for penetrating trauma with witnessed traumatic cardiac arrest while the patient is in the care of EMS or ED staff. There is very limited information on pediatric-specific thoracotomy. While the ATLS® does not give pediatric-specific recommendations, the Pediatric Trauma Society, Western Trauma Association, and Eastern Association for the Surgery of Trauma provide comprehensive pediatric thoracotomy recommendations.[55]

Thoracotomy allows for direct visualization and control of bleeding, lung repair, evacuation of massive hemothorax, and/or relieving cardiac tamponade. This procedure is contraindicated if the patient has had cardiopulmonary resuscitation (CPR) for >15 minutes without signs of life (defined as absence of cardiac electrical activity, respiratory effort, pupillary response, palpable pulses, measurable blood pressure, or extremity movement), severe brain injury, and clearly nonsurvivable multitrauma. Pediatric thoracotomy should not be performed unless there is surgical support or definitive surgical management within 45 minutes.[56,57] **See Table 4** for a step-by-step thoracotomy procedure.

The primary objectives of thoracotomy in the ED include controlling catastrophic hemorrhage, relieving cardiac tamponade, performing open cardiac massage during arrest, and cross-clamping the descending aorta to mitigate exsanguination from injuries below the diaphragm.[58,59] Indications for thoracotomy in the ED primarily include penetrating thoracic trauma in patients exhibiting witnessed signs of life upon arrival at a trauma center or within 15 minutes of CPR in the ED. The procedure entails a thoracic incision to provide direct access to the heart, lungs, and major blood vessels, enabling immediate surgical intervention.[58-61]

Thoracotomy is associated with overall poor survival outcomes; cautious patient selection and careful communication with surgical colleagues for pediatric thoracotomy is crucial.

Adult Studies

General survival outcomes for ED thoracotomies in adult patients are highly dependent on the mechanism of injury. Patients with penetrating trauma demonstrate relatively higher survival rates, ranging from 9% to 12%, with some studies reporting rates as high as 38%.[58] Conversely, survival rates following ED thoracotomy for blunt trauma are markedly lower, estimated in some studies at approximately 1% to 2%.[58,59] Given the time-sensitive nature of ED thoracotomy, clinical decision-making must be rapid and informed by a thorough assessment of the patient's physiological status, mechanism of injury, and likelihood of positive outcome, given these significant mortality figures.[58-61]

Pediatric and Adolescent-Specific Studies

There are very limited pediatric and adolescent-specific studies regarding ED thoracotomy. A 2012 retrospective cohort study of 29 pediatric patients showed that 3 patients survived, all with penetrating injuries to the heart, and all of these patients had signs of life on arrival of EMS. In this study, the survivors were adolescents (all aged 17 years), and the median age for the study was 15 years. Blunt trauma accounted for 45% of cases.[62] A 2016 single-institution review spanning 40 years of ED thoracotomy cases included 1691 patients. The survival rate among the 179 pediatric patients in the study was 3.4%, compared with 6.1% in the adult population. The pediatric population in the study included a much higher number of blunt-trauma–associated interventions, which likely accounted for some degree of the decreased survival.[63] A 2020 American College of Surgeons National Trauma Data Bank® study of 114 pediatric patients reported a 10% overall survival rate, and no survivors among the 53 patients who arrived without signs of life.[64] For

Table 4. Thoracotomy Procedure

1	**Preparation of the Room and Communication** • Increase room temperature. • Don personal protective equipment (required for all staff) • Prepare surgical equipment. • Communicate with surgical staff since immediate availability of transfer to an operating room is the goal of successful ED thoracotomy.
2	**Optimization of Resuscitation** • Stabilize the patient as much as possible. • Intubate the patient and prepare for surgical intervention while continuing all resuscitative measures, with as limited interruption in cardiopulmonary resuscitation as possible.
3	**Preparation for Incision** • Position the patient in a supine position with the left arm abducted. • Make a left anterolateral thoracotomy incision in the fifth intercostal space, extending from the sternum to the midaxillary line.
4	**Chest Entry** • Insert and open a rib spreader to provide adequate exposure to the chest cavity. • At this time, right mainstem intubation can potentially decrease obstruction of the left lung in the surgical field and could be requested by the operator performing the procedure.
5	**Pericardiotomy** • Identify the pericardium and open longitudinally, anterior to the phrenic nerve, to expose the heart (this step is crucial for relieving cardiac tamponade and allowing direct cardiac massage if needed).
6	**Cardiac Interventions** • Perform direct cardiac massage if the heart is not beating. • If ventricular fibrillation or shockable cardiac rhythm is present, consider internal defibrillation. • Identify cardiac wounds and control them using sutures, staples, or another mechanism of tamponade.
7	**Aortic Cross-Clamping** • Cross-clamp the descending thoracic aorta to control hemorrhage and maintain perfusion to the heart and brain.
8	**Hemorrhage Control** • Identify and control major intrathoracic bleeding sources as best as possible in this temporizing procedure. This may involve clamping or suturing of vessels or packing the thoracic cavity.
9	**Closure and Postprocedure Care** • Once the immediate life-threatening issues are addressed, temporarily close the thoracotomy incision. • Prepare the patient for transfer to the operating room for definitive surgical care.

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pediatric patients, ED thoracotomy should be carefully considered only in a patient presenting with witnessed loss of pulses or loss of pulses for <15 minutes.[64,65]

Special Populations

Obese Patients

Certain patient populations present unique challenges for diagnosing and managing pleural space pathologies. Obese pediatric patients may have subtle or atypical presentations, making clinical assessment, identification of procedural landmarks, and imaging more difficult. The use of ultrasound may be limited in obese patients, due to the loss of image quality when more adipose tissue is present, attenuating the ultrasound beam intensity.[66,77] Procedures such as needle decompression and chest tube placement can be technically challenging in obese patients, due to increased chest wall thickness, necessitating modified insertion techniques such as finger thoracostomy, larger incision, or increased catheter length.[4]

Patients With Secondary Pneumothorax

Secondary pneumothorax is defined as a pneumothorax that occurs secondary to underlying lung disease (eg, cystic fibrosis, asthma, infectious lung disease, or connective tissue disorders). Secondary pneumothoraces are typically more complex to manage.[68] In a retrospective cohort study of pneumothoraces in children with significant underlying disease, patients were found to experience prolonged air leaks, require longer drainage, and be at increased risk for recurrence, sometimes necessitating pleurodesis or surgical intervention, including thoracoscopy with pleurodesis or blebectomy.[68] Careful consideration of comorbidities and tailored management approaches are essential to optimize outcomes in patients with secondary pneumothorax.

Controversies and Cutting Edge

Ultrasound for Pathology Diagnosis and Procedural Guidance

Emerging research continues to refine the diagnosis and management of pleural space pathology, with ultrasound playing an increasingly prominent role in initial evaluation and procedural guidance. The Society of Critical Care Medicine recommends using ultrasound as an adjunct to chest x-ray to diagnose and localize pleural effusion, as well as to guide needle placement and assist fluid drainage.[69] It also recommends using ultrasound to assist with, or in some cases replace, chest x-ray for pneumothorax diagnosis, depending on the acuity of the clinical scenario.[69] A retrospective study found that real-time ultrasound guidance improved safety and reduced pigtail malplacement in children with parapneumonic effusion and empyema.[70]

Needle Placement During Decompression

The 2025 ATLS® recommendations state that needle decompression for a pediatric patient should be performed in the second intercostal space at the midclavicular line.[4] In adults, however, there continues to be debate over the optimal needle decompression location. The ATLS® guidelines recommend needle decompression at the fourth or fifth intercostal space just anterior to the midaxillary line for adult patients.[4] As a result, decompression in adults is still performed at both locations, reflecting an evolving practice that balances ease of access with anatomical considerations for effective decompression.[71] Transition from pediatric to adult placement site should be considered based on chest wall thickness and patient size. While there are limited studies outlining the exact age or weight of appropriate transition, pediatric chest wall thickness begins to approach that of adults at age 13 years.[44] It is the authors' collective opinion that clinicians should use the second intercostal space at the midclavicular line for pediatric needle decompression.

Needle Decompression and Chest Tube Placement Innovations

In recent years, chest tube placement kits have become available to improve the efficiency, accuracy, and safety of chest tube insertions. Although there are no well-established studies on newer thoracostomy kits that utilize the Seldinger technique (eg, pigtail catheter placement), these kits are being used in neonatal intensive care units and adult emergency medicine practices. There are a few options for commercially available chest tube insertion trays that allow for the insertion of a straight catheter using the Seldinger technique, and although some risks may be associated with the introducer, these tubes are frequently used for adult patients in EDs.[72]

For needle decompression, prepackaged devices that enhance ease of use have been used in pediatric and adult emergency settings; one commercially available product allows for easy access to a catheter-over-needle device specifically designed for decompression.

American and European studies have examined the sequelae of utilizing take-home chest tubes, including readmission rates, empyema development, and hospital length of stay. Ambulatory chest tubes, such as a Heimlich valve, have led to low readmission rates and decreased lengths of stay.[73] However, in cases in which the chest tubes remained for longer periods of time, adverse events such as readmission or empyema development were more likely to occur.[74,75]

Disposition

The decision to admit, discharge, or observe pediatric patients with pleural space pathologies depends on clinical stability, imaging findings, pain management, and the presence of associated injuries. The American College of Chest Physicians recommends that chest tubes be removed after a chest x-ray confirms lung re-expansion, in addition to improvement in vital signs and clinical presentation.[76]

Patients should be admitted for monitoring and continued treatment, particularly in the cases of thoracostomy, significant underlying lung injury, and ongoing respiratory distress. Patients are often observed for tube blockage or dislodgement, recurrent pneumothorax, worsening effusion, or infection.[77] A retrospective study suggested that while serial imaging is obtained to monitor for resolution, chest x-ray obtained after removing the chest tube rarely resulted in management changes, as immediate interventions and reinsertions are rare.[78]

While there are limited pediatric data on exact observation times, a consensus statement by the American College of Chest Physicians for adults asserted that clinically stable patients with a small pneumothorax can be observed in the ED for 3 to 6 hours, and subsequently discharged home if a repeat chest x-ray showed no progression.[76] However, in pediatric patients with pneumothorax, prolonged observation with repeat imaging is required and typically necessitates hospitalization. Discharge planning includes outpatient follow-up with the appropriate team(s), repeat chest x-rays, patient education, precautions to prevent recurrence, and possible future surgical planning.

Pediatric patients requiring chest tubes ideally should be transferred to a pediatric facility with surgical capabilities. A possible exception is an older adolescent patient with a spontaneous pneumothorax; however, if this patient is discharged, appropriate close outpatient follow-up should be in place. According to ATLS®, transfer should be considered for patients with moderate to severe thoracic injury who may benefit from the resources of a trauma center, even when surgery is not planned.[4] A 2025 retrospective cohort study of traumatic pneumothorax in children showed that smaller pneumothoraces (Collins method of measurement <12.5% on chest x-ray) may be appropriate for observation instead chest tube placement before transfer.[79]

■ Summary

There are many pleural space pathologies in pediatric patients that can present to the ED. When managing patients with pleural space diseases, it is imperative to consider a broad range of differential diagnoses and to diagnose and treat these patients in a timely manner. Initial management should include a thorough history and physical examination in conjunction with assessment of vital signs, as well as primary and secondary surveys in trauma cases. Although a rare occurrence in EDs, resuscitative thoracotomy should be conducted only if proper equipment and a trauma surgeon are available. Innovations such as the increasing use of ultrasound and thoracostomy kits can aid in the management of thoracic conditions, but they are areas of ongoing research.

■ Time- and Cost-Effective Strategies

- Community hospitals should implement clear protocols for the rapid transfer of patients requiring escalation of care. This includes patients who need thoracotomy, admission for ongoing monitoring, or transfer because adequate personnel or resources are not available.
- When placing chest tubes, consider the use of premade kits and/or ultrasound. These modalities have the potential to decrease procedure time, increase placement accuracy, and improve patient outcomes.

■ References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.

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Case Conclusions

CASE 1

For the 16-year-old boy with rib pain and shortness of breath after an all-terrain vehicle accident...

The chest x-ray confirmed a pneumothorax. You completed primary and secondary surveys, monitored his vital signs, and performed needle decompression. You then prepared for tube thoracostomy. The patient was properly positioned in a supine position with his ipsilateral arm extended over his head, the insertion area was properly cleaned, and adequate analgesia was administered. The tube was placed just above the rib in the fifth intercostal space at the midaxillary line. After securing the tube, chest x-ray confirmed adequate placement. The boy stayed in the intensive care unit for 2 days and then was transferred to the floor.

CASE 2

For the 16-year-old boy with increased work of breathing...

The patient was hemodynamically stable and in no acute distress. The nurse began supplemental oxygen, and a repeat chest x-ray showed an expanding pneumothorax. After a brief refresher on pigtail placement, you prepared the patient with adequate analgesia and anxiolysis, and you performed the pigtail insertion procedure using the Seldinger technique. You properly secured the tube to decrease the likelihood of complications from catheter movement after placement. The boy remained stable and was admitted to the floor.

CASE 3

For the 4-year-old girl with a gunshot wound to her right torso...

The patient was hypotensive, tachycardic, and in respiratory distress. You noted the gunshot wound was to the right upper thorax. The girl had absent breath sounds on the right and tracheal deviation to the left. You performed needle thoracostomy with an 8-cm catheter and heard a "whoosh" of air. There was immediate improvement in the degree of respiratory distress and in her vital signs. A chest tube was placed, and a subsequent chest x-ray showed appropriate endotracheal and chest tube position. You had notified the transport team prior to patient arrival, and the patient was safely transferred to a trauma center for continued care.

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Risk Management Pitfalls in the Emergency Department Management of Pediatric Patients With Pleural Space Pathologies

1. **"I performed needle decompression on my patient with a pneumothorax, and I executed tube thoracostomy. Adequate placement was confirmed on chest x-ray, but the patient still seemed to be uncomfortable."** Pain management is essential in pleural pathology interventions because untreated pain not only causes patient discomfort but can also cause worsening tachypnea and increased work of breathing.

2. **"I performed an emergency thoracotomy because I believed my patient required immediate intervention."** A thoracotomy should not be performed unless the appropriate resources are immediately available, such as an operating room, a properly trained surgeon, and adequate supplies. Since the procedure is a temporizing measure meant to deliver the patient to definitive treatment, a thoracotomy could also be considered contraindicated when being performed without the necessary equipment, including a manual internal defibrillator.

3. **"I conducted needle decompression on a patient with a pneumothorax in the ED. He stabilized, so I just monitored him. He began to decompensate not long afterwards."** Needle decompression offers immediate but short-term stabilization for tension pneumothorax. It is a life-saving intervention. The next step should be chest tube placement.

4. **"I placed a pigtail catheter in a small child. It kept kinking and did not drain properly."** Selecting the correct catheter size for pediatric patients is crucial. Small or improperly sized catheters increase the risk for kinking, malposition, and inadequate drainage. Always tailor the catheter choice to the patient's age, weight, and chest wall thickness, and confirm placement.

5. **"I was unsure whether to observe the small pneumothorax or discharge the patient after a short period of observation."** Even small pneumothoraces can rapidly progress in children, and this risk increases if there is no close monitoring. These patients should be admitted to the hospital for observation.

6. **"When the surgical team was preparing for thoracotomy, I saw that they were not wearing face shields."** One of the most frequent complications of thoracotomy is operator injury, and the first and foremost precaution should be utilizing the correct personal protective equipment. Strict usage of personal protective equipment dramatically reduces the risks for occupational exposures and injury.

7. **"While placing a chest tube on a 10-year-old with a right-sided empyema, I accidentally injured the heart."** Ultrasound guidance can assist in finding the optimal insertion site and avoiding cardiac structures, especially in smaller patients. Blunt dissection can also aid in reducing the risk for cardiac injury. Needle aspiration can be an effective form of management until surgical assistance is available.

8. **"I briefly saw a patient with pneumothorax that was confirmed on chest x-ray, but I don't know much more than that. He looked fine to me from the door."** To better understand the underlying cause of pathology, it is important to obtain a thorough history for a patient suspected of having a pleural space pathology.

9. **"I had a patient who fit the clinical description for a pneumothorax, but I didn't see a pneumothorax on imaging."** If there is strong clinical suspicion for a pneumothorax, a negative chest x-ray does not rule out a pneumothorax. Ultrasound and CT may be useful for diagnosis.

10. **"My patient with moderate pneumothorax was going to be transferred prior to chest tube placement, and I agreed to allow him to be transferred via fixed-wing aircraft to a children's hospital."** Caution should be exercised when transferring any patient with a pneumothorax, especially via a transport method at high altitude with an untreated pneumothorax. Intervention prior to transfer can prevent decompensation during transfer.

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5 Things That Will Change Your Practice

1. Real-time imaging using bedside ultrasound reduces complications and increases procedural success, especially for small or anatomically challenging chests.
2. Kits designed for pigtail catheter placement provide a minimally invasive option for pleural disease.
3. In children, the chest wall is thinner, and landmarks vary by age and body habitus. Accurate site selection is essential to ensure pleural access and avoid injury to internal structures.
4. Children can sustain significant pulmonary contusions or pneumothoraces without rib fractures. A normal-appearing chest wall examination or x-ray without fractures should not reassure the clinician when respiratory distress is present. Have a lower threshold for lung ultrasound or repeat imaging in symptomatic children after blunt trauma, even when initial findings seem mild.
5. Perform thoracotomy only when there was witnessed traumatic cardiac arrest, when cardiopulmonary resuscitation was performed for <15 minutes, and when adequate resources and support are immediately available. It is important that thoracotomy is performed by properly trained personnel, in a surgical environment, and with necessary equipment available.

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CME Questions

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1. **A 14-year-old boy presents with sudden-onset pleuritic chest pain and dyspnea while at rest. He is tachypneic but normotensive. Examination reveals unilateral decreased breath sounds and hyperresonance to percussion. What is the most likely diagnosis?**
   a. Empyema
   b. Pleural effusion
   c. Pneumothorax
   d. Pulmonary contusion

2. **A clinically stable 15-year-old girl with a small spontaneous pneumothorax has no hypoxia and minimal symptoms. What is the most appropriate management?**
   a. Immediate chest tube placement
   b. Needle decompression
   c. Thoracotomy
   d. Admit on supplemental oxygen and observe overnight

3. **A 12-year-old boy presents with tachypnea and unilateral decreased breath sounds after penetrating chest trauma. Chest x-ray confirms a large pneumothorax. The boy is hypotensive, with signs of respiratory distress. What is the most appropriate next step in management?**
   a. Observation with supplemental oxygen
   b. Immediate ED thoracotomy
   c. Needle decompression followed by chest tube placement
   d. CT scan of the chest prior to intervention

4. **According to 2025 ATLS® guidance, what is the recommended insertion site for pediatric needle decompression?**
   a. Fourth intercostal space, midclavicular line
   b. Fifth intercostal space, posterior axillary line
   c. Fifth intercostal space, midaxillary line
   d. Second intercostal space, midclavicular line

5. **A 9-year-old child requires needle decompression. Which needle specification is most appropriate based on age and body habitus?**
   a. 14 gauge, ≥8 cm
   b. 16 gauge, 6 cm
   c. 18 to 20 gauge, 3.2 to 4.5 cm
   d. 22 gauge, 2 cm

6. **After successful needle decompression of a tension pneumothorax, the patient's oxygen saturation and blood pressure improve. What is the next step in management?**
   a. Admit for observation
   b. Repeat needle decompression
   c. Thoracotomy
   d. Tube thoracostomy

7. **When placing a chest tube in a pediatric patient, which insertion location minimizes risk to the neurovascular bundle?**
   a. Fourth intercostal space below the rib
   b. Fifth intercostal space below the rib
   c. Second intercostal space, midclavicular line
   d. Fourth or fifth intercostal space, midaxillary line just above the rib

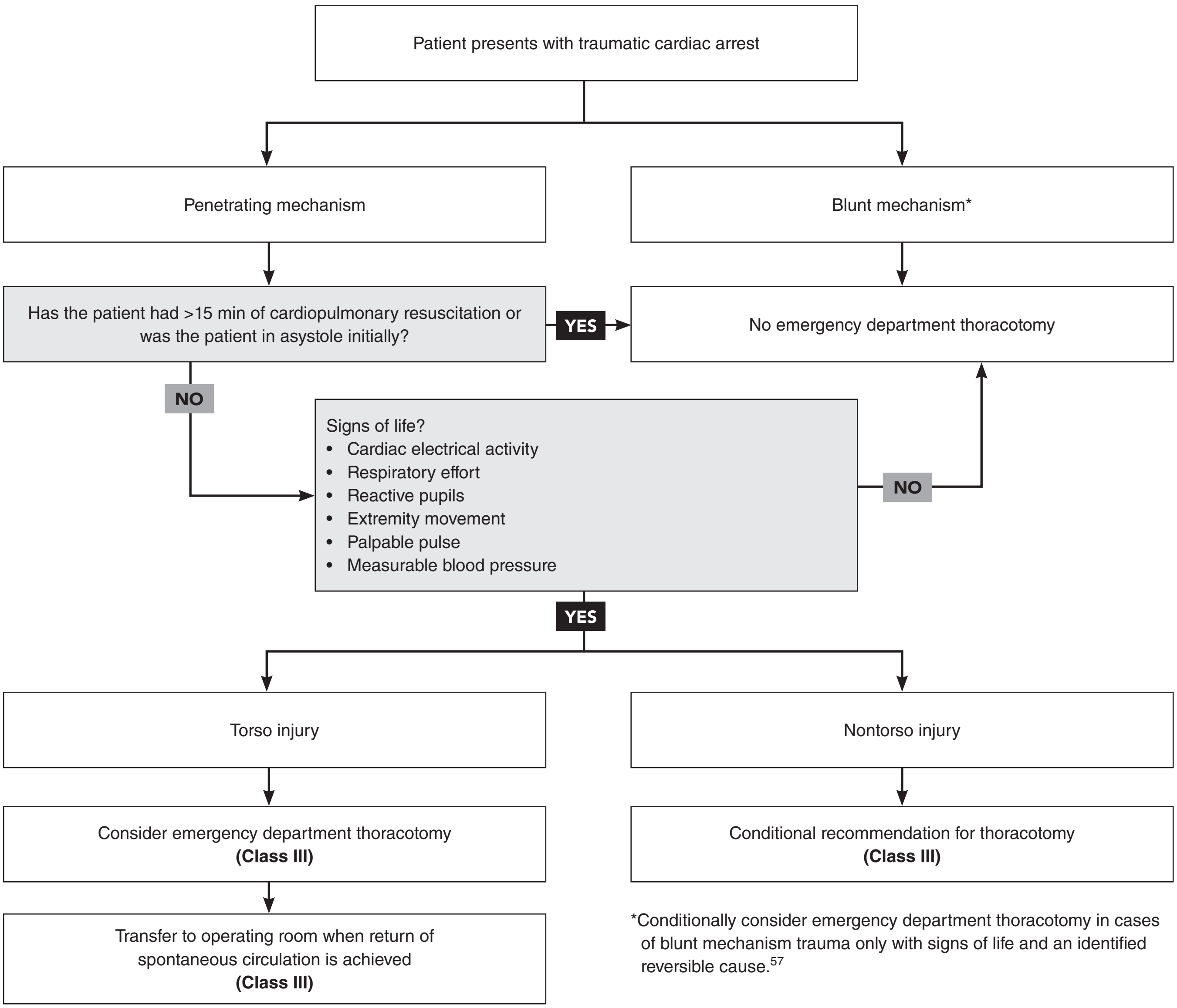
8. **Which of the following is an absolute contraindication to ED thoracotomy in pediatric trauma patients?**
   a. Blunt trauma mechanism
   b. Hypotension on arrival
   c. Cardiopulmonary resuscitation for >15 minutes without signs of life
   d. Penetrating thoracic injury

9. **Advantages of pigtail catheter placement over chest tube thoracostomy for the treatment of pleural space disease include all of the following EXCEPT?**
   a. Reduced need for opioid administration
   b. Decreased length of hospital stay
   c. Lower complication rate
   d. Improved drainage of empyemas

10. **A 17-year-old boy presents pulseless after a penetrating chest injury. Cardiopulmonary resuscitation (CPR) was initiated 6 minutes ago. He has organized electrical activity and reactive pupils. Surgical support is immediately available. What is the most appropriate next step?**
    a. Bilateral chest tube placement
    b. Continue CPR without intervention
    c. Obtain CT imaging
    d. Perform ED thoracotomy with a qualified staff (trauma surgeon) present

Clinical Pathway for Emergency Department Thoracotomy in Pediatric Patients With a Traumatic Plural Space Pathology

Click or scan for interactive pathway



Class of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

The *Pediatric Emergency Medicine Practice* Editorial Board

QUICK READ

Points & Pearls

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Thoracostomy and Thoracotomy for Emergency Management of Pediatric Pleural Space Pathologies

Points

- The differential diagnosis for pleural space pathology in pediatric patients is broad and includes spontaneous, traumatic, inflammatory, infectious, and iatrogenic causes.
- Initial management should include a thorough history and physical examination, as well as primary and secondary surveys in trauma cases.
- Chest x-ray is the first-line imaging modality for suspected pleural space disease, due to its rapid availability and low radiation exposure. ATLS® guidelines recommend using chest x-ray as the initial imaging modality, even though its sensitivity for detecting thoracic injuries in pediatric patients is relatively low.[4]
- Use ultrasound as the first-line diagnostic imaging modality when detecting small pneumothoraces and effusions and for procedural guidance.[25,26]
- Due to radiation exposure and limited impact on routine management, CT should be reserved for severe polytrauma and complex cases (eg, suspected bronchopleural fistula, necrotizing pneumonia, mass, or complicated effusions).[28,29]
- Pain control directly affects respiratory effort, oxygenation, and patient comfort, making early and adequate analgesia a key component of successful pleural space management.
- Multimodal analgesia and anxiolysis improves patient outcomes.[32] Combining nonpharmacologic strategies with local anesthesia and sedation can optimize patient comfort and cooperation.
- For a small pneumothorax in a clinically stable child, supportive care, including observation, rest, analgesia, and supplemental oxygen, may be adequate.[35,36]
- Select the thoracostomy approach and equipment based on the patient's size, pathology, and acuity.
- Adjust the procedural approach based on pediatric anatomy. Chest wall thickness and body habitus influence needle and tube placement. **(See Table 3.)**
- Needle thoracostomy is the first-line intervention for tension pneumothorax and should be performed prior to chest tube placement.

Pearls

- The "lung point" on ultrasound is pathognomonic for pneumothorax. **(See Figure 5.)** It is the interface between lung sliding and nonsliding pleura, and can guide accurate needle or pigtail placement.
- For small children, pigtail catheters have a higher risk for dislodgement or kinking. Secure the tube and use real-time imaging to reduce complications.
- Needle thoracostomy success depends on the catheter length and placement site. ATLS® recommends 2.5- to 4.5-cm needles for children, based on chest wall thickness.[4] **(See Table 3.)**
- ATLS® specifies the need for a large-bore over-the-needle catheter to be placed either in the second intercostal space at the midclavicular line or the fifth intercostal space between the midaxillary and anterior axillary line.[4] **(See Figure 6.)**

- Needle thoracostomy success should be determined by physiologic improvement, such as resolution of hypoxia and hypotension, not just by a subjective finding, such as a "gush of air."[48]
- Pigtail catheters are preferred for spontaneous pneumothorax and some effusions, due to their lower complication rates and reduced pain scores.
- Thoracotomy is a rare, high-risk intervention and should be performed by a trained physician at a location with immediate surgical support and proper equipment.
- Prepackaged thoracostomy kits and ultrasound have the potential to reduce procedural delays and improve patient outcomes.
- Postprocedure imaging can be used to confirm chest tube position and lung re-expansion, but routine imaging after tube removal rarely changes management.
- Pediatric patients with moderate to severe thoracic trauma, complex pleural disease, or those treated with thoracotomy should be transferred to pediatric centers with surgical support.

