Pediatric Thoracic Trauma

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Contents

14.1 Introduction

When treating pediatric trauma patients, many important differences must be considered when compared to adults. It may be difficult to have access to emergency vascular treatment especially in cases of shock or cardiac arrest. Interosseous access is an important option in all children and is more commonly implemented in the very young. Children have a smaller blood volume and a more insidious onset of hemorrhagic shock, commonly with tachycardia, as the only early warning sign.

Regarding thoracic injuries, children have a markedly compliant thorax making them vulnerable to intrathoracic injury without overlying bony injury. It is crucial to be vigilant while evaluating children with blunt trauma injuries. The pediatric mediastinum is also very mobile allowing it to be shifted with much less intrathoracic pressure. Susceptibility to tension pneumothorax or hemothorax is much greater and these injuries must be treated promptly. This mobility, however, does make it less susceptible to major vascular or airway injuries. Thoracic trauma in children is a marker for the presence of associated injuries, found in more than 50% of these children.

Children are much less likely to have concomitant systemic illnesses compromising their respiratory and cardiovascular reserves. This allows lower morbidity and mortality rates with aggressive medical therapy and faster recovery from injury.

14.2 Mechanism of Injury

Blunt trauma accounts for 85–90% of pediatric thoracic injuries. The majority of blunt thoracic injuries result from motor vehicle crashes. Children may be passengers

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in the motor vehicle or, frequently, may be struck by the motor vehicle. Falls from various heights are the next most common causes of thoracic injuries. Isolated blunt thoracic trauma carries a 5% mortality rate. When associated with blunt traumatic brain injuries, the mortality rate rises to 25%. When associated with brain and abdominal injuries, the mortality rate rises to 40%.

Penetrating trauma represents only 10–15% of thoracic trauma but the incidence increases with age, especially for children over 12 years of age. Nearly 14% of children suffering from penetrating thoracic trauma die from thoracic injury. Associated injuries with penetrating thoracic trauma are less common.

14.3 Immediately Life-Threatening Injuries Found During Primary Survey

14.3.1 Airway Obstruction

Airway obstruction can prove to be fatal if it is not treated immediately. Securing the airway is the first task in patient management. This takes precedence over all other needs and requires immediate attention and redirection if a patient's airway is lost during evaluation. Complete airway obstruction presents with a total absence of air movement and breath sounds. Partial obstruction presents with inspiratory stridor if the obstruction is above the vocal cords or expiratory stridor if the level of obstruction is below the vocal cords. Other signs and symptoms include agitation, diaphoresis, chest wall retractions, cyanosis, and bradycardia. Airway obstruction can occur from something as simple as a folding or closure of the normal hypopharynx, merely requiring a chin-tilt, jaw-thrust maneuver to reestablish a patient's airway. More serious causes of airway obstruction involve tracheal injury or foreign body aspiration. Unless an obstructed airway can be immediately cleared and ventilation reestablished, intubation is required. Non-cuffed endotracheal tubes are used and the size is determined by using the formula (age + 4)/4. If a child can be adequately ventilated with a bag-valve-mask, this allows for a more controlled intubation and repeat attempts if unsuccessful. If intubation cannot be achieved, a cricothyroidotomy must be performed. In children under 12 years, a needle cricothyroidotomy is accomplished by placing a large bore needle/angiocath through the cricoid membrane for temporary high flow oxygen administration followed by an immediate tracheostomy. In children 12 years or older an open cricothyroidotomy is done followed by a tracheostomy; after the patient is stabilized, other life-threatening issues are addressed and the secondary survey is completed. Foreign body aspiration requires airway control via endotracheal intubation followed by removal via rigid bronchoscopy (Fig. 14.1).

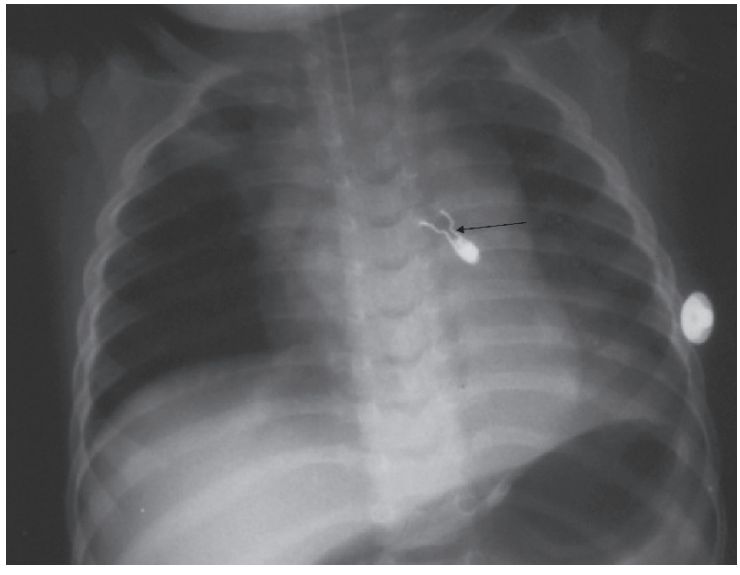

Fig. 14.1 Left bronchial foreign body

14.3.2 Tension Pneumothorax

A pneumothorax is caused by air entering the potential space between the visceral and parietal pleura resulting in air getting trapped in the hemithorax. This occurs following a tear in the pulmonary parenchymal due to rib fracture and laceration, deceleration injury, crush injury, or due to increased intrathoracic pressure causing pulmonary rupture. Signs and symptoms include chest pain, dyspnea, increased respiratory rate, and hyperresonance on the injured side. A pneumothorax can quickly result in cardiovascular demise if tension within the hemithorax develops (Fig. 14.2). Findings of hyperresonance, diminished breath sounds on the affected side, tracheal deviation, and hemodynamic instability indicate a potentially lethal tension pneumothorax requiring immediate intervention. Chest x-ray is not required to make this diagnosis and may waste valuable time. Needle decompression is the most efficient therapy for a tension pneumothorax; it is accomplished by placing a large bore angiocath in the second intercostal space along the mid-clavicular line just above the third rib. Alternatively, the decompression can be performed in the anterior axillary line just above the sixth rib. This should be followed by placement of chest tube. This results in the expansion of the lung and continued evacuation of air and fluid until the injured lung seals and air leak resolves.

14.3.3 Open Pneumothorax

An open pneumothorax is caused by a persistent or continuous communication between the environment and the chest cavity, and is sometimes referred to as a sucking chest wound. The negative intrathoracic pressure generated during inhalation results in air from the environment being sucked into the chest cavity and collapse of the lung on the affected side. Signs and symptoms include shortness of breath, chest pain, decreased breath sounds on the affected side, and sound of air being sucked into the chest cavity. This can result in respiratory arrest and cardiovascular collapse if not treated promptly. Treatment involves sealing or closing the hole in the chest wall. Vaseline gauze is commonly used. Placement of a chest tube evacuates residual air from the affected hemithorax and enables lung re-expansion. If there is an associated parenchymal injury, the chest tube is left in place until this air leak resolves.

14.3.4 Flail Chest

Flail chest is caused by multiple rib fractures or disarticulation of the ribs from the sternum resulting in an unstable segment of chest wall. The flail segment demonstrates paradoxical chest wall movement during the

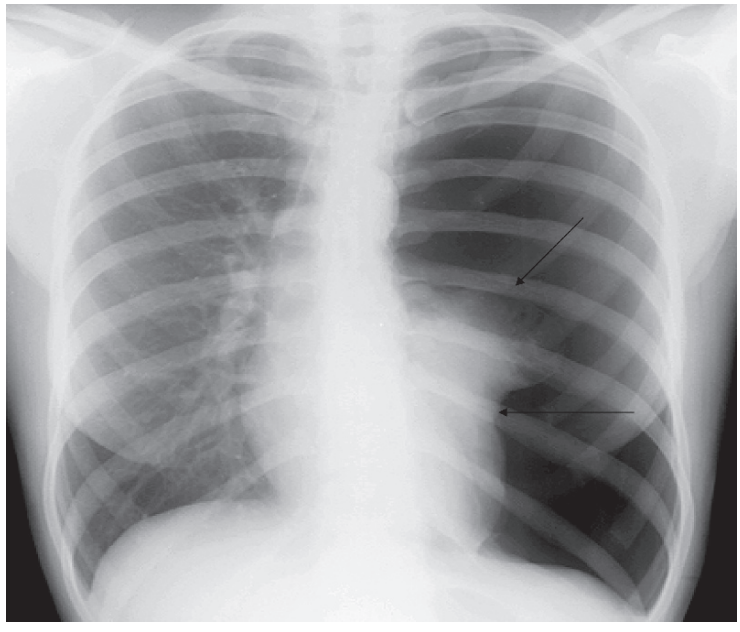

Fig. 14.2 Left tension pneumothorax with mediastinal shift

respiratory cycle and physical exam is diagnostic. Radiographic findings are only supportive. Treatment involves adequate analgesia, positive pressure ventilation, and possible rib fixation stabilizing the flail segment. Placement of chest tube may be required for associated pneumothorax or hemothorax. As with less complicated rib fractures, pain control and pulmonary toilet are essential.

14.3.5 Hemothorax

A traumatic hemothorax is the accumulation of blood in the hemithorax following blunt or penetrating trauma. Bleeding can result from rib fractures that lacerate the intercostal vessels, pulmonary parenchymal laceration, or, less commonly, great vessel injury. A massive hemothorax results from life-threatening exsanguination into the chest cavity requiring immediate intervention. Signs and symptoms include shock, hypotension, diminished breath sounds and dullness to percussion on the affected side, chest pain, shortness of breath, and oxygen requirement. This is a clinical diagnosis especially in the unstable child. In the stable child, a chest x-ray confirms the diagnosis (Fig. 14.3). Standard therapy includes large bore tube thoracostomy for evacuation of fluid and air providing for lung re-expansion. Resuscitation with intravenous fluid and possibly packed red blood cells is required. Thoracotomy is indicated for hemodynamic instability, loss of >25% total blood volume with initial chest tube placement, or persistent bleeding greater than 2 ml/kg/h.

14.3.6 Cardiac Tamponade and Commotio Cordis

Penetrating cardiac trauma quickly results in life-threatening injuries requiring surgical intervention. These are typically manifested by cardiovascular instability. Traumatic cardiac pericardial effusions and tamponade result from the accumulation of blood, fluid, or, rarely, air between the heart and the pericardium. This impairs cardiac filling during diastole. Signs and symptoms include muffled heart sounds, hypotension, distended neck veins (Beck's Triad), narrow pulse pressure, and pulsus pardoxus. Echocardiography in the Emergency Department (ED) is the radiologic test of choice and can help guide therapy. Emergency thoracotomy is required for cardiac repair and may be performed in the trauma bay for hemodynamic instability. Rib disarticulation from sternum may provide better exposure. A vertical pericardotomy is performed, with identification and repair of cardiac injuries with 5-0 nonabsorbable monofilament suture and pledgets. During pericardiotomy, care is taken to avoid the

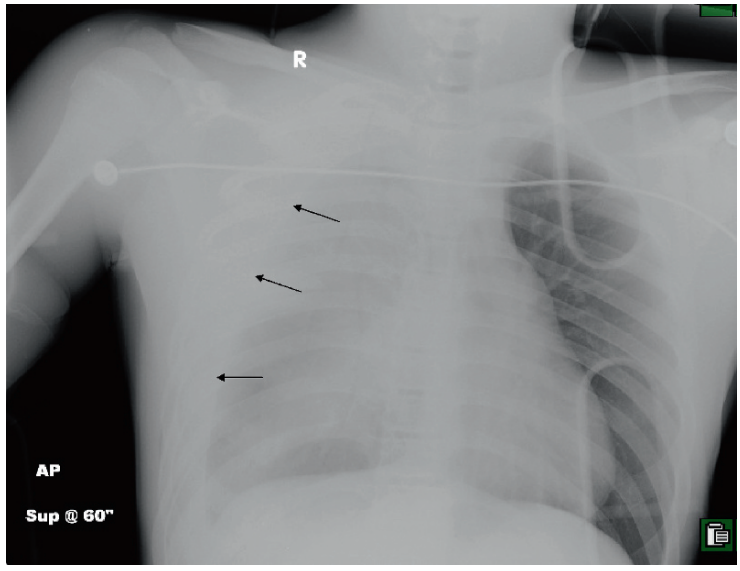

Fig. 14.3 Right hemothorax following a gunshot wound to the chest

phrenic nerve and the pericardium remains open after cardiac repair. In patients with equivocal signs and symptoms of pericardial effusion or tamponade, a subxyphoid pericardial window should be performed. This allows to assess the presence of blood or fluid within the pericardium. A note of caution to be ready for thoracotomy or sternotomy is warranted. Findings range from decompensation during pericardiotomy to finding blood in the pericardium (both necessitating thoracotomy) or a negative pericardiotomy. Pericardiocentesis is less commonly indicated but useful during resuscitation of an unstable patient with profound hypotension and suspected cardiac tamponade. A large bore needle/angiocath is inserted in the subxyphoid space at a 45° angle while aspirating with a syringe. If blood is obtained, the angiocath is left in the pericardial space while preparations for thoracotomy are made. Pericardiocentesis can be diagnostic and therapeutic but may result in further cardiac injury from needle instrumentation. Cardiac rupture due to massive blunt trauma is typically lethal.

Commotio cordis is a life-threatening arrhythmia resulting from a direct blow to the precordium. Several cases of precordial blows have been reported from sports such as baseball, softball, soccer, lacrosse, and karate. Commotio cordis triggers ventricular fibrillation or other fatal arrhythmias that quickly deteriorate. Defibrillation within 1–2 min results in 80–100% survival rates. Survivors have minimal to no identifiable laboratory abnormalities but usually have EKG abnormalities including S-T elevation or complete heart block.

14.4 Potentially Life-Threatening Injuries Found During Secondary Survey

14.4.1 Tracheobronchial Injury

Tracheal and bronchial injuries are uncommon in the pediatric population but have been reported following thoracic crush injuries and penetrating injuries. Signs and symptoms include chest pain, dyspnea, hypoxia, stridor, crepitance in the neck and chest wall, mediastinal air, tension pneumothorax, and hemoptysis. Placement of chest tube for pneumothorax results in identification of a large non-resolving air leak. Further diagnostic evaluation is best accomplished via rigid bronchoscopy for direct visualization of the injury and evacuation of blood and secretions. Eighty percent of these injuries typically occur within 2 cm of the carina in the trachea or mainstem bronchi and require early operative repair. Flap coverage of the repair with pleura or muscle reinforces and protects the repair.

14.4.2 Pulmonary Contusions

Pulmonary contusions are due to alveolar hemorrhage and parenchymal destruction. Pulmonary contusions, the most common injury found in children with thoracic trauma, can result from blunt or penetrating trauma. Only 40% of these patients have associated rib fractures. This low percentage is due to increased pediatric chest wall compliance. Signs and symptoms of pulmonary contusions include chest pain, shortness of breath, hypoxia, and, less commonly, hemoptysis. Pulmonary contusions may present insidiously during the first 24 h following thoracic trauma with worsening pulmonary symptoms and delayed radiologic findings. Chest x-ray remains the initial diagnostic exam and computer tomography is used for complicated cases when further imaging is required (Fig. 14.4). Treatment involves supplemental oxygen, fluid restriction as tolerated, chest physiotherapy to clear secretions and blood, as well as adequate pain control. Intubation and mechanical ventilation are infrequently required. The mortality rate due to isolated pulmonary contusions is low, and there are no long-term respiratory problems.

14.4.3 Myocardial Contusion

Substernal chest pain following blunt chest trauma is indicative of myocardial contusion. Other signs and symptoms include cardiac arrhythmias and hypotension. Myocardial contusion is the most common pediatric cardiac injury, accounting for 95% of blunt cardiac injuries. Motor vehicle accidents are the leading cause. Diagnostic evaluation reveals elevated cardiac enzymes and EKG shows S-T changes, arrhythmias, or heart block. Echocardiography may show wall motion

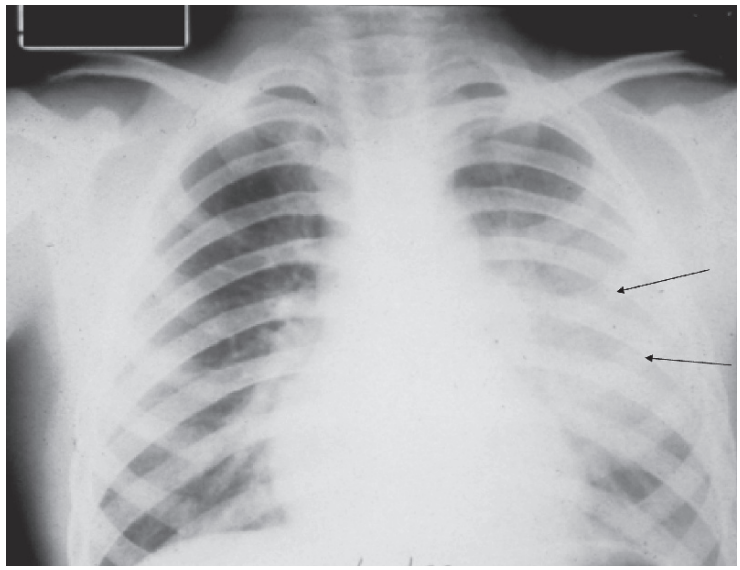

Fig. 14.4 Left pulmonary contusion due to blunt thoracic trauma

changes consistent with contusion or hematoma. Most injuries are self-limiting but can result in aneurysm formation and possibly cardiac rupture. Patients with myocardial contusions should be continuously monitored until free of arrhythmias for 24 h.

14.4.4 Diaphragmatic Injuries

Diaphragmatic injuries are more commonly caused by penetrating trauma. Signs and symptoms include dyspnea, abdominal pain, vomiting, and decreased breath sounds. These injuries can be diagnostic dilemmas. The initial radiologic exam consists of chest x-ray with a nasogastric tube (NGT) in place. With a left diaphragmatic injury, the stomach may be herniated into the chest and the NGT confirmatory of the injury. Helical computer tomography is currently the most useful exam with 70–100% accuracy. MRI is as accurate but commonly not available in the acute setting and requires much more time. This is costly especially during the golden hour. Up to one-half of diaphragmatic injuries are not found upon initial diagnostic evaluation. Nearly one-third are found intraoperatively, either incidentally or with minimally invasive surgical techniques. Isolated diaphragmatic rupture from blunt trauma is more common in children and occurs more frequently on the left side (Fig. 14.5). Primary surgical repair with nonabsorbable suture is most common; a patch is used if the defect is too large and not amenable to primary closure. Closure of larger defects with an intercostal muscle flap has also been accomplished.

14.4.5 Esophageal Rupture

Esophageal rupture is a very rare injury resulting from rapid elevation of intraluminal pressure. In cases of esophageal rupture, this is relieved by laceration of the wall rather than intraluminal dissipation. Signs and symptoms include chest pain, fever, subcutaneous emphysema, and dysphagia. X-rays may reveal subcutaneous air (Fig. 14.6). The resulting mediastinal sepsis can prove to be fatal if not diagnosed and treated promptly. Esophageal debridement, closure, and drainage remain the primary course of treatment.

14.4.6 Great Vessel Injury

Great vessel injury in the pediatric population is uncommon but can be devastating when the injury is not promptly recognized and treated. Aortic rupture is suspected with rapid deceleration injuries from motor

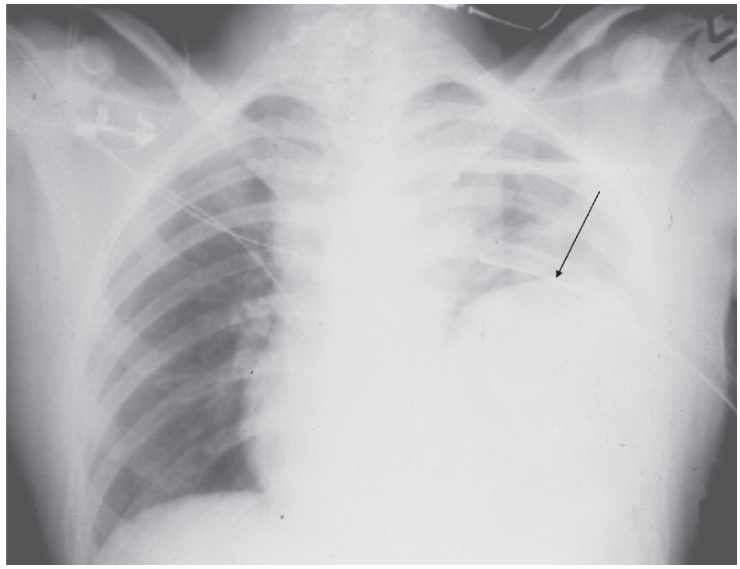

Fig. 14.5 Left diaphragmatic rupture

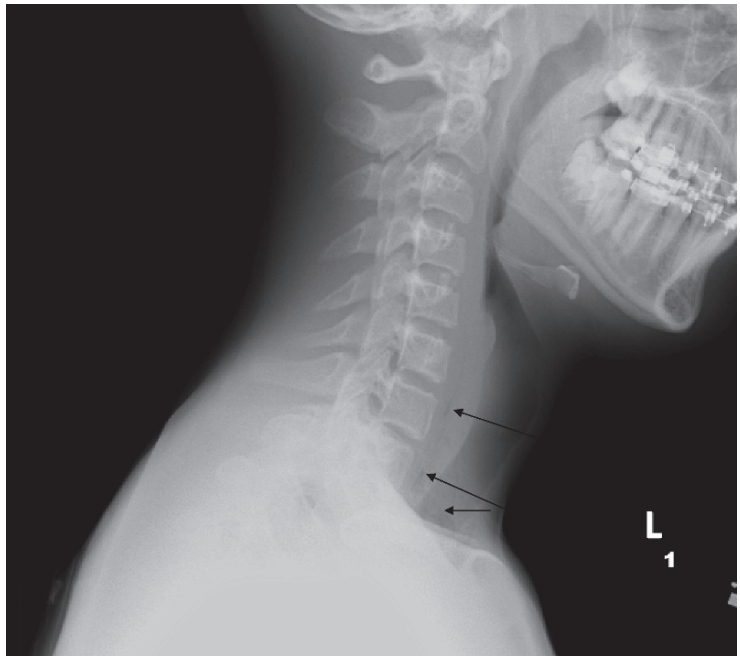

Fig. 14.6 Cervical soft tissue air and mediastinal air from esophageal rupture

vehicle crashes and falls from great heights. The most common site is at the level of the ligamentum arteriosum. Signs and symptoms include chest pain and hemodynamic instability. Chest x-ray may reveal a widened mediastinum, elevated left bronchus, loss of the contour of the aortic knob, first rib fracture, and deviation of the esophagus demonstrated with a nasogastric tube in place (Fig. 14.7). The diagnostic test of choice is arteriography but is commonly preceeded by helical computer tomography. Transesophageal echocardiography may also be useful. Treatment consists of aortic repair, commonly requiring cardiopulmonary bypass. Primary repair may be accomplished with nonabsorbable monofilament sutures with pledgets and vascular graft interposition

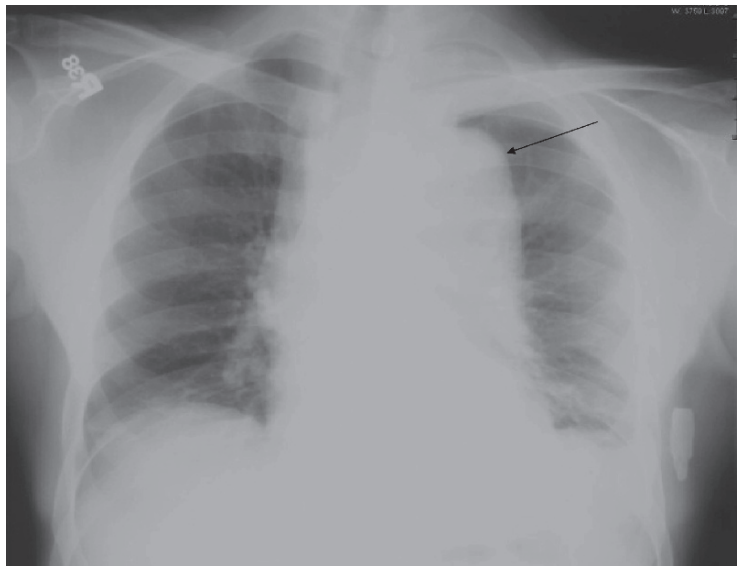

Fig. 14.7 Mediastinal widening and loss of aortic knob due to aortic rupture

may also be required. Branches of the thoracic aorta can usually be repaired without cardiopulmonary bypass.

14.5 Non-Life Threatening Injuries Often Found on Physical Exam or Chest Radiograph

14.5.1 Simple Pneumothorax

A simple pneumothorax occurs when air gets accumulated in the chest cavity without putting it in any tension. Decreased breath sounds may be observed as well as chest pain and shortness of breath. Chest x-ray is diagnostic and placement of chest tube is therapeutic (Fig. 14.8). In rare cases, a pneumothorax may remain very small due to a transient air leak from the parenchyma that readily stops. In this situation, conservative management may prevail without the placement of chest tube.

14.5.2 Small Hemothorax

A small hemothorax is caused by minor bleeding in the chest cavity due to pulmonary parenchymal injury or chest wall injury. Only the placement of a chest tube is required for drainage if the lung volume is compromised.

14.5.3 Rib Fractures

Rib fractures in children are less common than in adults due to the increased compliance of the chest wall. Therefore, rib fractures are felt to be a marker of increased injury severity. Rib fractures are also commonly associated with child abuse. Nearly two-thirds of rib fractures in children under three years of age result from abuse. The most common cause of rib fractures in older children are motor vehicle crashes. Signs and symptoms include chest pain, dyspnea, and splinting on the side of the fracture which can result in atelectasis and pneumonia. Chest x-ray will confirm the diagnosis and more importantly evaluate for an underlying pulmonary injury, pneumothorax, or hemothorax. Rib fractures typically require no surgical therapy. Pain control and pulmonary toilet significantly reduce the risk of complications from these fractures. Children with first rib fractures should be evaluated for vascular injury.

14.5.4 Chest Wall Laceration

Chest wall lacerations occur from multiple different mechanisms but the treatment remains the same. Wound exploration, foreign body removal, control of bleeding, debridement, and wound closure are the basics of laceration management.

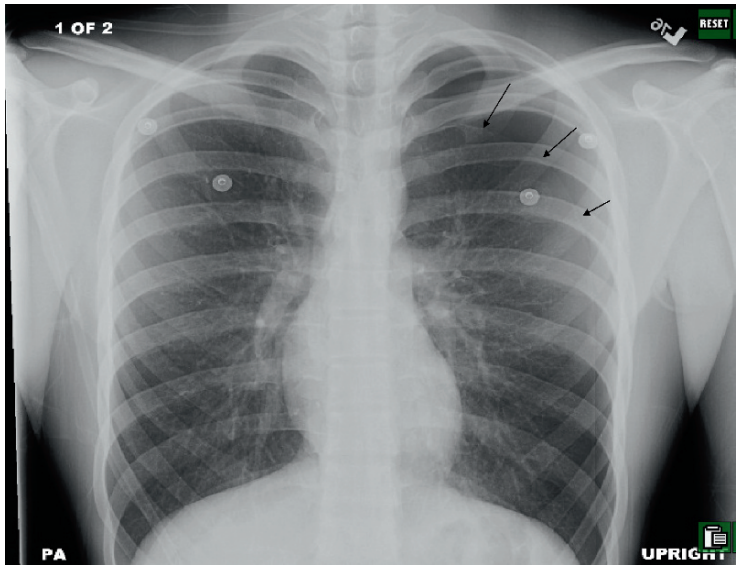

Fig. 14.8 Simple left pneumothorax

14.5.5 *Traumatic Asphyxia (Perthes Syndrome)*

Traumatic asphyxia is the inability to breathe due to compression of the thorax. Removal of the compressive force allows resumption of breathing and recovery. Commonly reported causes are compression from garage doors, motor vehicles, furniture, and other heavy objects. This results in global hypoxia most often rendering the patient unconscious followed by cerebral injury and death if the compression is not promptly relieved. Signs and symptoms include subconjunctival hemorrhage; facial, neck, and chest petechiae; and facial edema (Fig. 14.9). In hospitals, mortality rates are very low if these children survive the actual event.

Fig. 14.9 Subconjuctival hemorrhage, facial petechiae, and edema from asphyxia

Further Reading

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