Blunt Traumatic Lung Injuries
Daniel L. Miller, MD,*, Kamal A. Mansour, MD

*Section of General Thoracic Surgery, Department of Surgery, Emory University and The Emory Clinic,
1365 Clifton Road NE, Atlanta, GA 30322, USA

The first detailed description of chest trauma appeared in the Edwin Smith Papyrus in ancient Egypt circa 1600 BC [1]. In the fifth century BC, Hippocrates described hemothysis after rib fractures. He recognized that hemothysis indicated injury to the underlying lung, which was a more severe injury than a simple rib fracture [2]. Approximately one third of all patients admitted to major trauma centers in the United States sustain serious injuries to the chest. The lungs, which occupy a large portion of the chest cavity and lie in close proximity to the bony thorax, are injured in the majority of these patients directly or indirectly. A significant number of lung injuries are also associated with trauma to other critical thoracic structures. This article discusses blunt trauma injuries of the lung, which include pulmonary contusions, hematomas, lacerations, and pulmonary vascular injuries.

Pulmonary contusion

Pulmonary contusion is the most common injury seen in association with thoracic trauma [3]. It occurs in 30% to 75% of patients sustaining major chest injuries [4]. Pulmonary contusion is seen with blunt and penetrating wounds but is most common after motor vehicle accidents when the chest strikes the steering wheel or car door. The incidence of pulmonary contusions may be decreasing because of supplementary restraint systems, known as airbags, installed in US automobiles. Air bags supplement the safety belt by reducing the chance that the occupant’s upper body will strike the vehicle’s interior. They also help reduce the risk of serious injury by distributing crash forces more evenly across the occupant’s body. This decrease in lung injuries has been evident at Grady Memorial Hospital in Atlanta, Georgia, one of the busiest Level I trauma centers in the United States. From January 1, 2001 through December 31, 2006, a total of 8780 patients were admitted to the Emory University Trauma Service; 989 patients (11%) had an associated lung injury related to their trauma. Pulmonary contusions can also occur after falls from great heights or from blast injuries.

Isolated pulmonary contusions are encountered much less commonly than are contusions associated with other thoracic and nonthoracic injuries. Because pulmonary contusions are so commonly associated with other injuries, the pathophysiology of the associated injuries, the resuscitative and therapeutic measures that are necessary for their treatment, and the effects of aspiration, infection, and adult respiratory distress syndrome (ARDS) on the lung parenchyma have clouded the understanding of isolated pulmonary contusion.

Pathology

Wagner and colleagues [5] presented convincing evidence based on CT scan findings and limited pathologic material that a pulmonary laceration with resultant hemorrhage into adjacent alveolar spaces, rather than alveolar capillary wall injury, is the basis for the development of pulmonary contusions. They described four types of lacerations that are associated with pulmonary contusions. Type I lacerations are the result of compression...
of the elastic chest wall that causes the underlying air-filled lung to rupture. Type II lacerations result from compression of the lower chest wall that causes a sudden displacement of the lower lobe across the vertebral column and that produces a shearing tear in the adjacent lung. Type III lacerations are small peripheral lacerations that are close to rib fractures and are thought to be penetrating injuries caused by the ends of the fractured ribs. Type IV lacerations are tears caused by sudden chest wall compression that displaces the lung inwardly next to thick pleuropulmonary adhesions. Type I is the most commonly encountered laceration and is almost always seen in patients who are younger than 40 years of age. Type III lacerations are the next most commonly seen and usually occur in older patients.

Diagnosis

Blunt trauma to the chest, falls, and blast injuries should all suggest the possibility that a pulmonary contusion may occur. Dyspnea, tachypnea, hemoptysis, cyanosis, and hypotension are frequently seen. Physical examination may be unrevealing; however, in the presence of a severe contusion, inspiratory rales and decreased breath sounds may be found. A chest radiograph shows singular or multiple patchy alveolar infiltrates caused by intra-alveolar hemorrhage [6]. These patchy infiltrates can coalesce into homogenous infiltrates that involve a lobe or an entire lung. CT scans of the chest have been shown to be more sensitive in demonstrating the changes seen with pulmonary contusions than are routine chest radiographs [5]. In patients with pulmonary contusions, arterial PaO₂, alveolar arterial oxygen gradients, and pulmonary compliance are usually abnormally low. Hyperventilation may induce hypocapnia and respiratory alkalosis [7]. If the contusion is massive or if aspiration, infection, or ARDS develops, carbon dioxide may be retained and respiratory acidosis may ensue.

Treatment

Patients with pulmonary contusions should be hospitalized for careful monitoring because they can become critically ill rapidly. Oxygen should be administered as necessary to maintain arterial oxygen saturation greater than 90%. Patient-controlled analgesia, intravenous or epidural, should be used as necessary to control pain. Vigorous chest physiotherapy is important to keep the airway clear and help prevent the development of atelectasis. If ventilation is inadequate, intubation and mechanical ventilation are indicated. If large volumes of fluid are necessary for resuscitation, a pulmonary artery catheter should be positioned so that pulmonary artery pressures and pulmonary capillary wedge pressures can be measured.

The use of steroids and antibiotics is controversial. Some authorities advocate the use of high doses of steroids for a short time, whereas others believe that the use of steroids is not indicated [8]. Prophylactic antibiotics are used in some institutions; in others, antibiotics are used only when evidence of infection is present.

Pulmonary contusions are not innocuous injuries. In one series, 11% of patients with severe isolated pulmonary contusions died, whereas the mortality rate was much higher (22%) in patients with associated injuries [9]. ARDS developed in 17% of patients with isolated pulmonary contusions and in 78% of patients with two or more simultaneous associated injuries in other series [10].

Pulmonary lacerations

Pulmonary parenchymal lacerations, although seen more commonly after penetrating chest trauma, are also seen after blunt trauma. Although blood vessels and tracheobronchial passages may be disrupted, pneumothorax is in many cases the major problem, and bleeding is of minor consequence. If the laceration involves the visceral pleura and the communication with the pleural space remains patent, hemothorax, pneumothorax, or hemopneumothorax results. If the visceral pleura is torn but quickly seals, blood, air, or both can accumulate within the parenchyma and result in the development of a hematoma, cyst, or a cyst containing blood.

As a result of high-speed motor vehicle crashes, extensive pulmonary lacerations, occasionally with volvulus or torsion of the lung, are being encountered with increasing frequency. Such lacerations often are centrally located, are associated with severe chest wall injuries and pulmonary contusion, and disrupt large vessels and major bronchi.

Pulmonary hematoma

Pulmonary lacerations resulting from blunt or penetrating injuries may fill with blood, forming a pulmonary hematoma. The reported incidence
of hematomas developing in pulmonary contusions has ranged from 4% to 11% [5,11]. Because hematomas are recognized infrequently in clinical situations, the true incidence is likely to be less. Despite an unimpressive radiographic appearance, the injury represents a significant collection of intraparenchymal blood. It may not become visible radiographically for 24 to 72 hours after trauma resuscitation, during which time it increases insidiously. Pulmonary hematomas generally do not interfere with gas exchange, nor do they produce significant intrapulmonary shunting. Nevertheless, a pulmonary hematoma is a major risk factor for infection and lung abscess formation [12]. The use of CT scans permits more accurate evaluation of hematomas than conventional radiographs. On CT scans, hematomas have been found to shrink less than 0.5 cm in 3 weeks, whereas on conventional radiographs, they are reported to resolve within 2 to 4 weeks of injury [5]. In the absence of previous radiographs, serial films, or serial CT scans demonstrating the evolution of the hematoma, the exact nature of the nodule or lesion may be unclear, and the possibility of a neoplasm must be considered. If the nodule remains stable after 4 weeks, showing no evidence of resolution, fine-needle aspiration of the nodule or surgical excision should be performed to establish the nature of the lesion [13].

Management

In most cases, pulmonary lacerations heal promptly after chest tube insertion without any significant long-lasting ill effects. Peripheral lacerations encountered at operation can be oversewn (pneumorrhaphy), stapled, or wedged out. Extensive lacerations may be centrally located and may disrupt major vessels and bronchi. Resultant massive bleeding, large air leaks, and, although rarely seen, bronchopulmonary venous fistulas resulting in systemic air embolization require immediate operation. Proceeding to a thoracotomy is determined by the urgency of this situation, location of the injury, and structures presumed to be involved. Lately, more trauma centers are using thoracoscopy as a diagnostic or therapeutic procedure for pulmonary lacerations [14,15]; however, if a thoracotomy is required, hilar compression with the fingers and then with a large vascular clamp, such as a Satinsky or curved DeBakey, is used to control bleeding and air leak and to stop systemic air embolization. When the hilum is controlled, if embolization has occurred, air is aspirated from the left side of the heart, aorta, and coronary arteries. The vascular and bronchial injuries are then repaired, if possible, and the laceration is left open and drained with appropriately placed chest tubes.

Torsion or volvulus of the lobe or lung suggested by atypically oriented lobar collapse also necessitates prompt diagnosis and operation. At thoracotomy, the involved lobe or lung is untwisted and observed to ensure viability. If there is any question about its viability, the lobe or lung should be resected. Otherwise, the involved lobe should be stapled, if possible, to an adjacent lobe to prevent retwisting.

If a pulmonary hematoma or pulmonary contusion is identified at the time of thoracotomy, the surgeon should resist the temptation to resect the involved lung. Despite the gross appearance, there is rarely an indication for resection of an injured lung, unless there is associated significant injury to the airway or pulmonary vessels [16].

Pulmonary vascular injury

Vascular injury within the pulmonary parenchyma occurs within a low pressure system compressed by the surrounding parenchyma. Such hemorrhage generally stops with complete expansion of the lung [16,17]; however, uncorrected injury to the main pulmonary arteries or veins or to their principle lobar branches is usually lethal from rapid exsanguination because these structures bleed freely into the pleural space. Major pulmonary vascular injuries usually result from sudden deceleration. Mortalities rates for pulmonary arterial or venous injuries exceed 75%; therefore, the majority of these patients rarely survive long enough to reach a trauma center.

Management

If a major pulmonary vascular injury is diagnosed or suspected, control may be obtained at the pulmonary hilum by clamping the entire hilum. Through a thoracotomy incision, the hilum of the lung is grasped firmly with one hand as the surgeon uses the other hand to apply a long vascular clamp across the entire pulmonary hilum. This maneuver excludes the main pulmonary artery and veins from the circulation, may prevent exsanguination, and provides time for the anesthesiologist to resuscitate the patient. If there is a significant amount of blood in the airway, a double-lumen endotracheal tube or a bronchial
blocker may be used to protect the opposite lung from aspiration of blood. Next, the vascular injury should be isolated and repaired using standard vascular techniques [18]. If a lobar pulmonary artery is irreparable, it may be ligated without fear of pulmonary necrosis. The bronchial blood supply is usually sufficient to maintain parenchymal viability. If the venous drainage to a parenchymal region must be sacrificed, the involved parenchyma should be resected to prevent infarction of that portion of the lung secondary to venous obstruction [18].

Video-assisted thoracic surgery or thoracoscopy

Although most chest traumas do not require a major operation, tube thoracostomy remains the basis of treatment. Patients who would have required a thoracotomy in the past may actually benefit from a less invasive surgical technique to perform diagnostic and therapeutic procedures after blunt chest trauma. Improvements in instrumentation, especially endoscopic staplers and cameras, and endoscopic surgical techniques have expanded the indications for video-assisted thoracic surgery (VATS) or thoracoscopy in the diagnosis and treatment of diseases within the chest; however, the use of VATS remains controversial in trauma patients. Early publications explored the use of VATS in patients sustaining thoracic trauma [19,20]. The results were encouraging, but the series reported a small number of cases. In 1999, a meta-analysis of the use of thoracoscopy in trauma was published that involved 28 studies and more than 500 patients. The complication rate was 2% and the missed injury rate 0.8%. The most important benefit was that 62% of patients did not require a thoracotomy or laparotomy for diagnosis or treatment of their thoracic injuries [21]. VATS is an accurate and effective modality in the evaluation and management of hemodynamically stable patients who experience thoracic injuries. One should have a low threshold to perform an open procedure if the situation arises. A relative stable thoracic trauma patient can become extremely unstable at any moment; therefore, one should be prepared to proceed with a thoracotomy immediately. Caution should also be taken in the thoracic trauma patient with multiple injuries, especially severe intra-abdominal injuries.

Blunt thoracic trauma continues to be a significant cause of morbidity and mortality in the United States. A comprehensive evaluation of these patients is needed to improve their survival. Understanding the lung injuries that can occur related to blunt chest trauma is essential to improved outcomes. The use of VATS in blunt thoracic trauma has improved the diagnosis and management of patients with life-threatening pulmonary injuries.

References


