Tracheobronchial Injury in Blunt and Penetrating Chest Trauma*

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Ten patients were seen in Northern Syria with tracheobronchial injury from June 1986 to July 1988. Eight were male; and five were children. Blunt trauma was the cause of rupture in five and penetrating trauma in five. Nine patients had associated injuries. In seven, the diagnosis was made within 24 h. The seven patients who had surgery were well at last follow-up, as was a child with a main bronchial tear who was treated conservatively. Two men died without having surgery, one of respiratory failure and sepsis and the other of hemorrhagic shock. The group's mean age was 17.5 years. The average hospital stay was six days (eight for survivors), and the follow-up period was seven months. The clinical presentations and outcome stress the essential role of early chest x-ray and bronchoscopy, as well as a high index of suspicion.

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Key words: airway injury, chest trauma-wounds, tracheobronchial injury-rupture

At the time of bronchoscopy, the left main bronchus (LMB) tapered to a point 2 cm from the carina. Thoracotomy was undertaken when consent was given two weeks later. Dense adhesions obliterated the aortopulmonary window and separated the blind ends of the avulsed LMB by 3 cm. Infected drain sites and difficult dissection necessitated pneumonectomy. The child was discharged 4 days after operation and 14 months later was seen thriving.

CASE 2

A family car carrying 14 passengers crashed into a truck one evening. Of the nine survivors, a girl aged 10 years who had been thought to be dead on arrival in the hospital had dyspnea, hemoptysis, and cyanosis. Tube thoracotomy had failed to expand her collapsed, “fallen” right lung. Bronchoscopy confirmed total rupture of the right main bronchus (RMB) and separation of the ends by 2.5 cm. At thoracotomy, the bronchus was sutured. At discharge 9 days later and at a follow-up visit 18 months later, the right lung remained fully expanded.

**FIGURE 1.** A chest x-ray film of the patient in case 1 taken hours after admission. It shows total descent of the left lung to the diaphragm (arrow). The lung occupies the lower medial quadrant of the left hemithorax.

**MATERIALS AND METHODS**

Ten patients with TBI were managed between June 1986 and July 1988 in four hospitals in Aleppo, Syria. None of these hospitals had facilities for blood gas measurement, portable x-ray machines, or postoperative ventilation. Furthermore, there was no organized transport or trauma system. Clinical data for the patients are listed in Tables 1 and 2.

Rigid and flexible bronchoscopy instruments were taken to the hospitals by the surgeon. Thoracotomy was performed with the rigid bronchoscope sterilized. Orobronchial intubation with a single-lumen endotracheal tube was accomplished by passing the tube into the noninjured bronchus over a small bougie (gum elastic 8-12 Fr) left in position at bronchoscopy. A double-lumen endotracheal tube often was unavailable or too large for children. Integrity of bronchial closure was tested by withdrawing the single-lumen tube into the trachea and applying positive pressure ventilation. Interrupted polyglactin or polyglycolic acid suture was used in airway repairs and polypropylene suture in cardiovascular repairs.

**CASE REPORTS**

**CASE 1**

A boy of 11 years old was seen three weeks after he had been run over by a cart and admitted to the hospital with respiratory distress, extensive surgical emphysema, and cough. A chest x-ray film had shown a left tension pneumothorax (Fig 1). Total collapse and descent of the left lung followed and persisted despite insertion of a series of thoracotomy tubes. Complete radio-opacification of the left hemithorax, with mediastinal shift to the left, later ensued. On examination, the frail boy had two infected drain sites.

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Tension multiple breaks bronchoscopy revealed Steinmann pins. Emphysema necessitating a Consent and incompletely pulmonary artery apical segmental subluxation of the third costal x-ray was showed worsened the Suction pneumothorax. A the and his skin drain was withheld. Right chest lobe collapse the lung. The air leak ceased at 9 days, the drain was removed, and the child was discharged on day 10. He was last seen 6 weeks later with a normal chest x-ray film.

Case 3
A boy 4 years old was hit by a car and admitted to the hospital in severe respiratory distress, with subcutaneous emphysema and cyanosis secondary to bilateral pneumothoraces (Fig 2) and fractures of the right eighth and ninth ribs. He had bilateral pleural drains inserted. Bronchoscopy 4 days later, for right upper lobe collapse and persistent air leak, showed a 1.5-cm tear of the RMB reaching the upper lobe orifice. Bronchoscopic removal of debris expanded the lobe. The air leak ceased at 9 days, the drain was removed, and the child was discharged on day 10. He was last seen 6 weeks later with a normal chest x-ray film.

Case 4
A youth aged 16 years was hit with a ball on his right breast, collapsed, and his skin coloring became dusky. An hour later in the hospital, he was hypotensive and had a right tension pneumothorax. A chest tube drained air and 600 ml of blood. Suction worsened the dyspnea and failed to reexpand the lung. Bronchoscopy showed incomplete avulsion of the right upper lobe bronchus. Consent for thoracotomy was initially withheld. Right thoracoscopy showed marked contusion of the lung, an air leak from a hilar hematoma, avulsion of the internal thoracic vessels, and subluxation of the third costal cartilage. At thoracotomy, a torn apical segmental vein was ligated, the severely contused right pulmonary artery reinforced with autologous pericardium, and the incompletely torn right upper lobe bronchus was repaired. He was discharged 8 days later, and was well with a normal chest x-ray film 13 months later.

Case 5
A 37-year-old man was admitted to the hospital with dyspnea, multiple right rib and sternal fractures, a lung contusion, and head and facial bruising, 36 h after being rescued from a wrecked bus. Hamman's sign was positive but he was stable. Hours later, after a bout of heavy coughing, he suddenly developed alarming subcutaneous emphysema and became acutely dyspneic. Urgent bronchoscopy revealed a longitudinal right lower tracheal tear necessitating immediate thoracotomy, with left bronchus intubation. Tension pneumomediastinum and pneumohemothorax were released. The 1.5-cm tracheal tear was sutured. Multiple breaks in the third through ninth right ribs were fixed with Steinmann pins. Pulmonary lacerations were sutured. Sputum retention required bronchoscopy on the second day. A minor wound infection delayed hospital discharge until the ninth postoperative day. He remained well 4 months later.

Case 6
A youth of 17 years who was stabbed in the left posterior axillary line in the seventh intercostal space sought medical attention the following day. A left tension hemopneumothorax was drained, but the chest tube had a continuing air leak. Three days later, thoracotomy revealed a 5-mm stab wound of the LMB which was repaired. Lacerations in the upper lobe, the lower lobe and the diaphragm were repaired, and the partially severed seventh intercostal bundle was ligated. His recovery was uneventful.

Case 7
A girl aged 6 months, while sitting on her mother's lap at a wedding, was hit by a bullet from a pistol fired for joy. The bullet, after bouncing off the ceiling and a wall, traversed the left second intercostal space, mediastinum, and middle lobe (ML), causing a right tension pneumothorax (Fig 3). A pleural tube was inserted immediately. At thoracotomy, the deformed bullet was lying free in the pleural cavity and the air leak was traced to the severed medial segmental bronchus of the ML for which a segmentectomy was done. The infant was discharged 7 days later and had a normal chest x-ray film 6 weeks later.

Case 8
A man aged 22 years who was stabbed medial to the right breast, presented with dyspnea, hemoptysis, and hypovolemic shock. A pleural tube drained 4 L in as many hours. Bronchoscopy was nondiagnostic. After insertion of a double-lumen endotracheal tube, a right thoracotomy showed laceration of the pericardium, atrial appendage, internal thoracic vessels, and the ML, and an oblique, near complete transection of the RML bronchus and artery. Lobar bleeding was controlled with sponge tampon-
was the second showed obstruction of the bronchus and collapsed He hemoptysis. loss through phsyema, Three later, he entered his chest and was not bleeding vessels and the cultured,  

*Age 6 months for case 7. 
†Four days at referring hospital.

ade, while the pericardium was opened, the atrial laceration sutured, and the right pulmonary artery exposed. The internal thoracic vessels were then ligated and the ML resected. Minor wound infection delayed hospital discharge until the ninth day, and 3 months later he had a satisfactory chest x-ray film.

**CASE 9**

A bullet from a pistol entered a 22-year-old man’s second left intercostal space anteriorly and exited medial to the right scapula. Three hours later, he was conscious but in shock. A chest x-ray film showed marked mediastinal widening with mediastinal emphysema, but no pneumothorax or hemothorax. At bronchoscopy, a bleeding jagged defect in the anterolateral part of the mid-trachea was seen. Efforts to resuscitate the patient failed, and an autopsy was not done.

**CASE 10**

A 36-year-old man was shot with a high-velocity bullet which entered his chest through the right shoulder and exited through the left axilla and caused paraplegia. Bilateral hemopneumothoraces were managed with bilateral tube thoracostomies. Four days later, he developed septic shock, respiratory distress, cyanosis, and hemoptysis. He had an air leak on the left and significant blood loss through both drains. Radiologically, the lower lobe was totally collapsed and the right partially so. Immediate bronchoscopy showed obstruction of the LMB by a mucopurulent blood clot. He died shortly afterward. At autopsy, the left apico-posterior segmental bronchus and adjacent vessel were found severed as were the second right intercostal bundle and large prevertebral veins. There was compression of the spinal cord by a hematoma.

**RESULTS**

Six patients were operated on within 72 h of injury, but surgery for one was delayed for 5 weeks. One patient with blunt chest injury was treated nonsurgically because consent for operation was withheld. Two patients died with bullet wounds: one died before thoracotomy could be performed and the other, who also had spinal cord injury, had been referred 3 days after injury with respiratory failure and sepsis and died shortly after bronchoscopy.

The preoperative diagnosis of TBI was made on the basis of the medical history, clinical examination, chest x-ray film, and bronchoscopy (diagnostic in five of eight cases), and thoracoscopy in one case.

**Table 2—Significant Clinical Findings**

<table>
<thead>
<tr>
<th>Type of Trauma</th>
<th>Blunt</th>
<th>Penetrating</th>
<th>Total Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Cough</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Hemothysis</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Shock</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Surgical emphysema <em>(1)</em></td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

*Mediastinal emphysema. 
†Tension pneumothorax. 
‡Bilateral pneumothorax.
Of the seven patients who had surgery, it was possible to repair or reimplant the injured segment in four. Segmental resection was performed in one patient and a lobectomy in another. One child required a pneumonectomy at 5 weeks.

**Discussion**

In 1977, Bates\(^1\) stated that a thoracic surgeon in Britain may see two TBIs over 30 years of practice. Tracheobronchial injuries afflict up to 2.8 percent of severe blunt chest trauma\(^2\) and accidental deaths.\(^2,3\) Only 2 to 3 percent of all published cases\(^6\) are of the penetrating type, yet they comprised half this series. Females become less frequent victims after their second decade.

Owing to improvements in transportation and trauma management, the overall mortality of TBI has been reduced to under 30 percent.\(^7,16\) Until Krinitzki\(^3\) reported the first long-term human survivor in 1927 when TBI had been thought to be uniformly fatal. Most patients die within a few minutes of injury because of inadequate airway, tension pneumothorax, and associated damage to vital structures. Associated injuries are more common in penetrating than in blunt trauma and generally afflict 50 percent of victims,\(^6\) or three per individual in fatal accidents.\(^9\) They indicate severity of the trauma.\(^9,11\) Two associated injuries per patient were seen in this series, with the rare pulmonary vessel damage occurring on three occasions.\(^9\) Both mortalities in this report were in the high-risk gunshot wound group.\(^11\)

Rapid anteroposterior compression of the chest is a common factor in most TBIs.\(^3,6\) It may pull the lungs apart avulsing a bronchus\(^5,7\) (case 1), or it may abruptly increase airway pressure resulting in rugged, “burst” TBIs\(^5,8,9\) (cases 2, 3, and 5). Trauma may be trivial,\(^7,10\) but a history of compression is suggestive.\(^6\) Iatrogenic elevation of airway pressure appears to rupture alveoli instead,\(^9\) perhaps because of the slower increase in pressure. Rapid deceleration and shering forces may further contribute to the etiology.\(^7,10\)

Burke\(^14\) divided the post-injury period into two phases: hematoma formation and development of stricture. A third phase of maturation of the fibrous stricture and its sequelae may be added. It starts in the third or fourth weeks after injury. Total disruption of a bronchus favors its complete occlusion and begets atelectasis,\(^14\) usually sterile, which may be amenable to surgical repair years later.\(^10,17-19\) This was regrettable not possible in case 1, owing to complete loss of tissue planes and infection. Pulmonary resection may not be the initial preferred procedure for a torn bronchus but is practical in a setting where support services are limited. Partial occlusion of the injured bronchus ultimately leads to suppuration and bronchiectasis necessitating resection in a quarter of cases.\(^2,10,14,16\) Four of the five blunt trauma tears in this series were within 2.5 cm of the carina,\(^14\) confirming Laplace’s law:\(^20\) pressure in the wall of a hollow structure increases with increase in its radius. Tracheobronchial injuries are more common on the right side,\(^1\) perhaps because the aorta protects the LMB, or aortic injury may lead to reduced survival.

Although the diagnosis of TBI can be made on clinical grounds, aided by bronchoscopy, this may be difficult since the clinical manifestations of TBI are protein\(^9\) and the symptoms, signs, and investigations can all be nonspecific.\(^14,21\) Presentation depends on the site and size of the air leak, and whether it communicates with the pleura.\(^7,10,11\) In the commoner communicating type,\(^10,11\) there is usually an ipsilateral pneumothorax with a large air leak and atelectasis, despite adequate pleural drainage. Suction may increase the dyspnea.\(^9\) Cases 5 and 9 had no pleural communication, and in them surgical emphysema, hemoptysis, and cough were less evident and pneumothorax was absent. However, the picture may change suddenly (case 5). Most of the patients of this series exhibited emphysema, pneumothorax, hemoptysis, and rib fractures singly or in combination.\(^6,14\) Dyspnea and cough were experienced by almost all ten patients. Surgical emphysema (seen mainly in the blunt trauma group) is significant especially when seen in the deep cervical plane in a chest x-ray film.\(^7,12,16,22\) Also, on the chest x-ray film the “falling lung sign”\(^23\) is pathognomonic of total rupture of a main bronchus (cases 1 [Fig 1] and 2). Rib fractures seem to accompany TBI only when they afflict the upper five ribs and in those patients more than 30 years of age.\(^14\) Beyond the acute phase, exertional dyspnea may be the only symptom, although, with partial stenoses, sepsis may have varied manifestations.\(^21\) Ten percent of cases may have little evidence of thoracic mischief,\(^6,14\) and only a third reach a definitive diagnosis within 24 h\(^2,6,7,14,16\) and then only because they are either critically ill (11 percent) or fail to respond to treatment (21 percent).

Immediate management should address the presenting problem rather than the exact diagnosis, since airway injury *per se* seldom causes rapid death. Respiratory distress may be relieved by intubation\(^22\) or by inserting a rigid bronchoscope.\(^12\) In this service, the rigid bronchoscope was the single most important piece of equipment, for in addition to procuring a definitive diagnosis in most instances and providing a temporary airway it facilitated selective bronchial intubation\(^22\) (cases 2 and 5). Bronchoscopy should be performed under operating room conditions for mere suspicion of injury.\(^1,6,7,20,21\) Emergency thoracotomy may be undertaken for an air leak compromising respiration\(^9\) (case 5) or hemorrhage (case 8).
pulmonary artery injury may remain occult, its prophylactic control before exploration is advisable.24

Early primary repair, first performed successfully by Sanger in 1945,25 eliminates stricture formation and is the procedure of choice.6,7,11,15 Repair of small bronchi is rewarding if technically feasible8,9,14,20 (case 4). However, extensive damage may necessitate resection.4,7,9,12,22 Modern absorbable suture is preferable for bronchial repairs because if anastomoses do not heal within a few days they are unlikely to heal by primary intention later. Nonabsorbable suture may cause tissue granuloma2,7,22 and erode into the lumen.4 Peripheral tears, as well as those measuring less than the diameter of the injured bronchus, may be managed nonsurgically3,7,11 (case 3), but the outcome may be uncertain,16 since a stricture may form at a later date.

Griffith21 demonstrated the feasibility of secondary repair in 1948 and this should always be attempted,10,11,17,18 although functional success becomes unpredictable with time.26 Fibrosis and entrapment may end in resection,11 however (case 1).

Ultimately the decision to operate and the choice of operation will be influenced by the capabilities of the hospital, including monitoring devices, diagnostic aids, and treatment modalities, eg, epidural analgesia and antibiotics. These facilities usually are taken for granted in industrialized countries but were difficult to obtain in the setting of this experience.

Postoperative ventilation, common in a few series,4,12,22 was fortunately not required by any of the seven patients who had surgery. The mean hospital stay of 6.2 days compares favorably with other series4,22 from more sophisticated centers, and the follow-up of 7 months was considerably shorter. These were due partly to financial considerations.

CONCLUSION

Tracheobronchial injuries are serious and potentially fatal. Their manifestations are variable and protean and misdiagnoses are common. Diagnosis depends on vigilance in any significant chest trauma regardless of severity, a chest radiograph, and bronchoscopy. Good results can be expected with early surgical repair, despite limited resources and facilities, while later intervention is less predictable.

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