Surgical treatment of post-traumatic tracheobronchial injuries: 14-year experience

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Abstract

Objective: Tracheobronchial injuries have different clinical pictures and high mortality unless aggressive treatment is used. We reviewed our surgical experience. Methods: The records of 32 patients from 1988 to 2002 were reviewed. Mean age was 22.3 years (range: 4–53). Three patients were female. Prominent symptoms were dyspnea, subcutaneous air and pneumothorax in chest X-rays. Associated injuries were seen in 22 patients (68.7%): most frequently in the lung parenchyma (11 patients) and esophagus (seven patients). Bronchoscopic detection of a rupture of the trachea or bronchus was the main indication for surgery. Results: Nineteen injuries (59%) were penetrating and 13 blunt (41%). The most common presenting sign of airway disruption was subcutaneous emphysema (25%) and stridor (22%). Of the 32 patients, 22 underwent bronchoscopic examination. Bronchography was used in three patients admitted during the late period. Surgical morbidity was 19.3%. Seven patients died (21.8%), of whom six had been operated on. In operations performed during the first 2 h of trauma, no mortality occurred. There were associated injuries in 100% of patients that died and in 60% of those that survived. The proportion (100 vs. 24%) and duration (2.8 vs. 11.6 days) of ventilatory support were lower in patients that survived than in those that died. Mean injury severity score of patients that died was 34.7 ± 8.8 while it was 24.3 ± 8.6 in those that survived. Tracheal stenosis developed in three patients (9.3%). Conclusion: In civilian life, tracheobronchial injuries occur relatively rarely. Early diagnosis and operative intervention save lives. Associated injury is an important mortality factor. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Tracheobronchial injury

1. Introduction

Tracheobronchial injury (TBI), a rare but potentially fatal condition, results from blunt/penetrating chest or neck trauma and has different clinical pictures [1–4]. The position of the trachea relative to the mandible, sternum and vertebral column protects it from injuries and explains the rare occurrence of these injuries. The cartilaginous support, mobility and elasticity of the trachea provide extra protection. Easy access to weapons (firearms and knives) along with the spread of violence has increased both homicides and attempted homicides [5]. During recent decades, an increase in traffic accidents has caused an increase in blunt TBIs [6]. Although emergency services and transport have improved, many patients still die before reaching the hospital [7,8]. Thus prompt recognition and aggressive treatment is of utmost importance [9–11]. However, it is very difficult to draw conclusions about treatment methods.

This report reviews our 14-year experience with patients who sustained major airway disruptions after blunt and penetrating thoracic trauma, with a focus on patterns of injury and management issues.

2. Materials and methods

Information was obtained by reviewing the operative records and archive files from 1988 to 2002 at the Dicle University School of Medicine Department of Thoracic and Cardiovascular Surgery. The group consisted of 32 patients with penetrating or blunt TBIs who reached the emergency department. All injuries involved the trachea or the main stem bronchi. All patients reached the hospital alive and underwent surgical debridement and primary repair, but one was lost when intubation was performed. A rupture of the trachea or bronchus, detected bronchoscopically, was the main indication for surgery, as well as observing massive and permanent air leaks from the tube.
or injury site, and acute respiratory distress after the trauma indicating airway rupture. Rigid bronchoscopy was used for diagnosis in all cases. Emergency operations after an X-ray and chest tube insertion (without further diagnostic examination, four cases) were performed in patients with acute suffocation. All patients were evaluated by flexible bronchoscopy at the postoperative days 2, 3 and 4 to evaluate anastomosis line and remove secretions. Flexible bronchoscopy was also performed one and two weeks after the operation to detect stenotic scarring. Blood gas analysis was performed in all ventilatory supported patients. Cardio-respiratory insufficiency with CO₂ retention and decreased O₂ level resistant to positive end-expiratory pressure was diagnosed as acute respiratory distress syndrome (ARDS). Attention was paid to the mechanism of injury, presenting symptoms, associated injuries and diagnostic modalities. Surgical morbidity and mortality were analyzed.

### 3. Results

Thirty-two patients with TBIs were identified among approximately 8600-thorax trauma patients treated by the hospital trauma service (overall 14-year incidence of 0.37%). Mean age was 22.3 years (range: 4–53). Six patients were under 15 and four under 10 years old. There were 29 males and three females. No iatrogenic injury was present. Six patients were intubated in the emergency department and four patients were admitted to the hospital intubated. Nineteen of the injuries were penetrating (59%) and 13 blunt (41%). The most frequent causes of the TBIs were guns (56%) and traffic accidents (28%). The mechanism and localization of injuries are shown in Table 1. The most frequent sites of injury were the trachea (56%) and main bronchus (31%). Six were injured in the right main bronchus and three in the left. In one patient, two main bronchi were injured and in one patient, the trachea and left main bronchus were involved.

#### 3.1. Findings and diagnosis

The most common presenting signs of airway disruption were subcutaneous emphysema (25%) and stridor (22%). Two (6.2%) patients had flail chest (Fig. 1). Roentgenography was the most commonly used diagnostic method in all cases and the findings were shown in Table 2. Esophagograms with contrast were studied in seven patients in whom we suspected esophageal injury, but four of them showed leaks from the esophagus. Of the 32 patients, 22 underwent bronchoscopic examination. Indications leading to clinical suspicion of airways injury were subcutaneous air in seven

![Fig. 1. Physical findings in patients with tracheobronchial injury.](image-url)
(32%) patients, extended or massive air leak in four (18%), stridor in five (23%), dyspnea in four (18%), and hemothorax in two (9%). Bronchoscopy was diagnostic in all with the view of disrupted or lacerated tracheal tissues, clots or holes. Bronchoscopy was the most useful diagnostic tool because it helped to detect the level of injury. In all patients that underwent bronchoscopy, a diagnosis was established. In ten patients, bronchoscopy was not performed because of diagnosis was established with clinical evaluation (dyspnea associated with air escaping from the neck wound, massive air leak from the chest tube, pneumothorax refractory to chest tube, subcutaneous air, etc.). Side of injury and X-rays were helpful in pointing out the side and level of airway injury. Evident air leak in the injured region in five (neck three, thorax two), emergency operation in four, death during resuscitation in one, and hemo-pneumothorax by roentgenography were specifications of the non-bronchoscopy patients. After the initial chest tube insertion, massive air leaks and no improvement in dyspnea lead to thoracotomy of the injured side.

Bronchography after bronchoscopy was used in three patients admitted during the late period (1, 4 and 7 months after trauma) and was diagnostic in all, showing right main bronchial cutoff in two, and left main bronchial cutoff in one. Indications of bronchography in a patient with total atelectasis of the involved side and dyspnea with trauma history were used to clarify the bronchoscopic findings and documentation. Computed tomography (CT) was performed in two patients and no specific finding was detected.

Fifty-three associated injuries were seen in 27 patients (84.4%): 17 of them (63%) had blunt TBI and ten (37%) penetrating TBI. Most frequently, the lung parenchyma (11 patients) and esophagus (seven patients) were the associated injury sites (Table 3). Abdominal and brain CTs were useful to detect associated injuries, as well as esophagograms and X-rays. In eight patients, mini-laparotomy was performed to explore the abdomen. Five (15.6%) patients had no associated injury (isolated TBI), and no one died.

3.2. Operations and follow-up

Thoracotomy was performed in 59.3% of the patients, sternotomy in 6.2%, clamshell in 3% and cervical incision in 31.2%. Bilateral thoracotomy was performed in a patient with right and left main bronchus injury caused by a long knife. Of the 18 tracheal injuries, two were complete tracheal ruptures (transsection), both from blunt traffic injuries; seven were lacerations and nine were lateral injuries. Of the ten main bronchus injuries, four were transections, three were lacerations and three lateral injuries. Lobar bronchus injuries were lacerations. No small airways tears (<1/3 of the circumference) were present.

Our technique for a complete tracheal separation was to pass the endotracheal tube across the lacerated trachea and to complete the repair over the endotracheal tube, as well as the partial injuries. For transactions of the main bronchus, selective intubation of the non-injured main bronchus was applied. All injuries were repaired completely, except in one soldier who needed a second operation. Management of blunt or penetrating injuries was not different. There was a total of six complete circumferential injuries (tracheal two, main bronchus four). End-to-end anastomosis was performed to maintain airway for all. Of the two patients with complete tracheal rupture, one underwent thoracotomy and the other cervical incision, and uneventful postoperative and follow-up periods occurred after the primary end-to-end anastomosis. Release maneuvers by dissecting and mobilizing the hilum and incising the inferior pulmonary ligament were used to decrease tension in the patient that underwent thoracotomy because of large amounts of tissue require debridement. But ventilatory support after repair of the bronchi was established because of spontaneous respiratory insufficiency. However, septic shock with high fever developed and the patient was lost on the third postoperative day. In three late cases, complete transection of the main bronchus and bronchial anastomosis was performed. Because of contraction of the bronchus due to scar tissue and circumferential resection (0.5–1 cm) for obtaining the fresh wound edge, release maneuvers were needed to decrease anastomosis tension. One of them remained atelectatic after anastomosis. Bronchial stenosis was detected bronchoscopically 11 days afterward. Esophageal perforations (cervical four, thoracic three) were closed primarily, simultaneous to airway repair. In two cervical esophageal injuries, fistulization developed. Cessation of oral intake and antibiotic pressure with cervical drainage were successful. In one of three thoracic esophageal injuries, a stenosis

<table>
<thead>
<tr>
<th>Table 3: Associated injuries</th>
<th>No.</th>
<th>Surgical intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thoracic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung injury</td>
<td>11</td>
<td>Primary suturation 7, tractotomy 4</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>7</td>
<td>Chest tube</td>
</tr>
<tr>
<td>Esophageal tear</td>
<td>7</td>
<td>Primary suturation 4, muscle-pleura flap + suturation 3</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>4</td>
<td>Chest tube</td>
</tr>
<tr>
<td>Flail chest</td>
<td>2</td>
<td>Ventilatory support 1, fixation 1</td>
</tr>
<tr>
<td><strong>Non-thoracic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head injury</td>
<td>4</td>
<td>Hematome evacuation 1</td>
</tr>
<tr>
<td>Vascular injury (axillary 2, subclavian artery 1)</td>
<td>3</td>
<td>End-to-end anastomosis 2, saphenous interposition 1</td>
</tr>
<tr>
<td>Gunshot wound (other than thoracic)</td>
<td>2</td>
<td>Finger amputation 1</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>2</td>
<td>Fixation</td>
</tr>
<tr>
<td>Bone fractures</td>
<td>5</td>
<td>Fixation</td>
</tr>
<tr>
<td>Splenic injury</td>
<td>1</td>
<td>Splenectomy</td>
</tr>
<tr>
<td>Hepatic</td>
<td>2</td>
<td>Suturation</td>
</tr>
<tr>
<td>Gastric</td>
<td>1</td>
<td>Partial gastrectomy</td>
</tr>
<tr>
<td>Rectal</td>
<td>1</td>
<td>Primer suturation + loop sigmoidostomi</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>1</td>
<td>Fixation</td>
</tr>
</tbody>
</table>
was observed after 3 months. The others were uneventful. In all operations, non-absorbable suture was used, usually Prolene. One upper lobe resection was performed, in a right bronchus rupture. The upper lobe parenchyma was contused and lacerated extensively by blunt trauma; no ventilation occurred after bronchial repair while the other lobes were well ventilated.

Features of surgery are summarized at Table 4. Surgical morbidity was 25.8% (8/31). For atelectasis and extended air leak, bronchoscopic aspiration, respiratory exercises and chest percussion were useful. In cases with pneumonia, antibiotics according to blood and sputum cultures were beneﬁcial. Regular dressing twice a day and antibiotics were used to alleviate wound infection within 2 weeks.

Seven patients died (21.8%). Mortality was 30.7% (4/13) in patients with blunt trauma and 15.8% (3/19) in those with penetrating trauma. Six of them had been operated on; thus surgical mortality was 19.3% (23% for blunt, 15.8% for penetrating). There was no mortality in the operations performed in the ﬁrst 2 h of trauma. Six hours after the trauma, operative mortality increased noticeably (Table 5). No death was directly related to airway injury. All patients lost had received ventilatory support for a mean of 11.6 ± 4.4 days. Twenty-four percent of survivors received ventilatory support (longer than 12 h) (6/25) and mean ventilatory time was 2.8 (1.4–17) days. The proportion of patients receiving ventilatory support and its duration was lower (P < 0.05) in survivors. The most frequently used method for ventilatory treatment was synchronized intermittent mandatory ventilation (SIMV). Associated injuries were present in 100% of the patients that died and in 60% of those that survived (P < 0.05). Mean injury severity score was 34.7 ± 8.8 in patients that died and 24.3 ± 8.6 in those that survived (P < 0.05).

Mean follow-up period was 11.8 months. In three patients (9.3%), tracheal stenosis identiﬁed bronchoscopically developed. The indication for bronchoscopy was stridor.

4. Discussion

The infrequency and occult clinical nature of such injuries often result in a delay in diagnosis [12]. Many patients with traumatic rupture of the tracheobronchial tree die before reaching the hospital [13]. Failure to recognize an injury to the upper airway may be life-threatening in the acute phase and may lead to severe long-term morbidity related to phonation and airway patency [1,11,12]. In our series, the most frequently recognized ﬁnding was subcutaneous emphysema. No patients were asymptomatic. The most useful diagnostic method was bronchoscopy. In a patient with respiratory distress, trauma anamnesis and subcutaneous emphysema, bronchoscopy is useful for making a diagnosis. Aggressive use of bronchoscopy in the appropriate clinical setting will result in earlier diagnosis of tracheobronchial disruption and improved patient management.

TBI in children is only reported sporadically. The chest wall of a child is very pliable, and external forces are transmitted directly to the intrathoracic structures [14]. Our six children with TBI underwent surgery, and no deaths occurred. Only one complication (atelectasis) was observed. Persistent atelectasis may occur in TBI in children [15].

Definitive investigation of the patient with a suspected laryngeal or tracheal injury depends upon the airway status on arrival at the hospital and the presence or absence of associated injuries. If the patient is stable, radiologic investigations should include plain radiographs of the chest, cervical spine and cervical soft tissues [12]. Patients with penetrating injuries require careful evaluation of all adjacent

Table 5

<table>
<thead>
<tr>
<th>Hours</th>
<th>B (13)</th>
<th>P (19)</th>
<th>T (32)</th>
<th>Mortality</th>
</tr>
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<tbody>
<tr>
<td>0–2</td>
<td>3</td>
<td>3</td>
<td>6 (18.7%)</td>
<td>(0%)</td>
</tr>
<tr>
<td>2–6</td>
<td>6</td>
<td>8</td>
<td>14 (43.7%)</td>
<td>(7.7%)</td>
</tr>
<tr>
<td>6–24</td>
<td>3</td>
<td>6</td>
<td>9 (28%)</td>
<td>2 (15.4%)</td>
</tr>
<tr>
<td>&gt;24</td>
<td>1</td>
<td>2</td>
<td>3 (9.4%)</td>
<td>2 (15.4%)</td>
</tr>
</tbody>
</table>

* B, Blunt; P, penetrating; T, total. Numbers in parentheses indicate numbers of patients.
structures for potential injury. All esophageal perforations were caused by penetrating injuries. Esophagographies can be diagnostically useful.

Tracheostomy is mostly unnecessary [16]. Once the endotracheal tube is satisfactorily in place, the surgeon has the option of repairing the trachea primarily without tracheostomy [8]. Only during the postoperative period and in patients connected to ventilatory support for longer than 4 days (five patients) did we perform it. Primary anastomosis without concomitant tracheostomy is preferred [8].

The vast majority of tracheal injuries can be managed through a cervical incision. Not only can the trachea be well visualized from the neck incision, but also many of the associated injuries can be managed with less morbidity than through a thoracic approach. Furthermore, the larynx is easily approached should mobilization be required [5]. The best chance of successful repair of tracheal injuries occurs when all devitalized tissue is removed and primary closure without tension is performed as the initial procedure. The two factors that have the greatest bearing on successful repair are the tension on the suture line and the vascular supply to the wound edges [5]. The treatment of choice is primary suture closure. It is believed that the use of local muscle flaps to buttress the trachea and separate the trachea from the esophagus is an important technique in the management of combined injuries of the trachea and esophagus [16], but this is not a totally dependable technique; tracheoesophageal fistula can develop or recur after placing muscles [17,18]. We did not use this technique because the combined injuries we encountered had a rich supply with good bleeding from wound edges. On the other hand, no enormous debridement was needed and we used non-absorbable monofilament sutures to secure strict closure of the wound. Monofilament non-absorbable sutures were less likely to be associated with suture line infection while polyfilament material was found to have a distinctly increased bacterial affinity relative to monofilament material [19,20]. Thus they can prevent wound dehiscence by infection better than absorbable ones. Furthermore, no side effect (granuloma etc.) has been observed [18], which is consistent with our experience.

Primary suturing and end-to-end anastomosis of the bronchus for complete trans-section was sufficient. An additional airline for the distal part of the rupture was applied when exposure was carried out for complete transections. A double lumen tube was not used mainly due to the problem of its availability in emergencies. For the second operation (posterolateral thoracotomy) after an anterior thoracotomy, and for a late case, a double lumen tube was used.

In three patients (9.3%), stenosis developed. One of them was associated with total lung atelectasis of the involved side. The other two suffered from some exercise dyspnea. Successful repair of chronic laryngeal and tracheal stenosis remains inconsistent and disappointing [12]. New-generation spiral CT or high-resolution CT may be superior to bronchography to detect bronchopulmonary lesions. We performed bronchography to detect late stenosis in old dated cases that these facilities were not present.

If irreversible pulmonary parenchymal destruction presents, and if bronchial injury is extensive or the rupture is situated in a small bronchus then resection may be necessary [6,13]. Extensive upper lobe damage unrelated to airway injury was present in one case. A lobectomy was performed. Injuries to the large airways distal to the lobar divisions are best treated by lobectomy because these injuries are rarely isolated. However, we isolated and repaired them successfully for all four cases without lobectomy.

Unfortunately, gunshot injuries also are associated with more complications than stab wounds because not only are more tracheal rings destroyed by the bullet itself, but also the blast effect produces tissue damage beyond the margins of the visible injury [5]. There was no difference between the two kinds of injuries in terms of mean morbidity. Morbidity was 11.4–35% in the literature [5,8,16] and 25.8% in this study. Only pneumonia and empyema had an effect on hospital stay.

Mortality varies from 4 to 30% [2,5,8,16] in the literature and surgical mortality was 19.3% in our study. Mortality was 23% in patients with blunt rupture and 15.8% in those with penetrating rupture. Although statistically incomparable, the higher mortality caused by blunt rupture indicates the importance of associated blunt injuries, especially on the lungs, causing ARDS. Most studies emphasize the importance of early diagnosis and surgical intervention. Accordingly we have seen an increase in mortality with delayed surgery. In addition, higher injury severity scores and more associated injuries were observed in patients that died.

In conclusion, TBI demands urgent measures to treat airway damage. Bronchoscopy should be performed in all suspected patients. Operative management can be performed with acceptable mortality. Meticulous repair can be achieved with non-absorbable monofilament sutures. Early diagnosis and treatment minimize the risk of infection and resection.

References


