Repair of Tracheobronchial Injuries

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KEYWORDS

• Tracheobronchial injury • Airway management • Iatrogenic tracheal laceration
• Mediastinal emphysema

KEY POINTS

- Establishment of a secure airway is the first step in the management of non-iatrogenic tracheobronchial injuries followed by control and repair of vascular and other life threatening associated injuries.
- Operative tracheobronchial reconstruction is mandatory in penetrating injuries and when there is associated esophageal injury or mediastinitis is evident.
- Conservative treatment in patients with incomplete tracheal membrane laceration (TML) and case-by-case decision making in full-thickness TML is recommended, depending on the severity of the accompanying problems and patient condition.
- Endotracheal reconstruction of TML could be a possibility in experienced centers in the future for all patients who tolerate jet ventilation.

Videos of complete intraluminal repair of a iatrogenic tracheal laceration and expiratory tracheal collapse in the region of a former tracheal membrane laceration accompany this article at http://www.thoracic.theclinics.com/

INTRODUCTION

Tracheobronchial injuries (TBIs) are a heterogeneous group of injuries in terms of the trauma mechanism, anatomic site of damage, and severity of subsequent respiratory complications (**Table 1**).[1] TBIs are often life threatening and require early and skillful airway management, careful evaluation, and qualified operative repair, which is best offered in thoracic surgery units.[2] The most important discrimination of TBI is traumatic damage versus iatrogenic tracheal laceration. Iatrogenic tracheal lacerations are rarely accompanied by esophagus rupture, whereas blunt or penetrating injuries of the tracheobronchial tree are most often accompanied by a variety of different and sometimes life-threatening injuries.[3] Therefore, the 2 types of injury are described separately in this article. Intubation-associated injuries and blunt trauma account for the most events in the Western countries. Penetrating injuries predominate in war zones.

NONIATROGENIC TBI

Statistics

Blunt and penetrating injuries often occur with other injuries, especially those of the great vessels; without early recognition and prompt intervention, they are frequently fatal. The prognoses of patients who reach hospital mainly depend on airway management and the extent of associated injuries. Blunt trauma is most frequently (59%) caused by motor vehicle accidents, and the mortality is around 9%.[4] The incidence of TBI after blunt trauma is low (2.8%), as was found in a postmortem analysis by Bertelsen and Howitz.[5] Another study showed an even lower incidence of 0.5%.[6] Of all the blunt TBI cases reviewed by Symbas

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Table 1
Pathomechanism of tracheobronchial injuries

Blunt trauma	Traffic accident	Dashboard injury, deceleration with shoulder belt
	Burying	Thoracic compression
	Fall	Deceleration, direct cervical injury
	Crush injury	Compression, rib fractures, cartilage fractures
	Hyperextension of the cervical trachea	Distraction injury, laryngotracheal separation
Penetrating injury	Gunshot	Transmission of kinetic energy
	Stabbing	Sharp tissue transection
Iatrogenic	Intraoperative	Excision of wall structures, devascularization
	Postintubation	Direct longitudinal laceration

and colleagues,[7] 136 (71%) had transverse ruptures, 33 (18%) had longitudinal ruptures, and 14 (8%) had complex ruptures. Almost 75% to 80% of penetrating injuries involve the cervical trachea, whereas 75% to 80% of blunt injuries occur within 2.5 cm of the carina and 43% occur within the first 2 cm of the right main bronchus.[4,7] Intrathoracic blunt TBI is regularly associated with other organ involvement.[8] Thus, 80% of accident victims with evidence of TBI die before reaching hospital.[9] The distribution of TBIs in Germany was described by Schneider and colleagues[2]; 58% were iatrogenic and 41% were traumatic in origin. From the 429 cases of noniatrogenic origin, 276 (64%) were caused by blunt trauma, 94 (22%) had penetrating injuries, and 16 (4%) had gunshot injuries in a 5-year observation period. All bullet injuries and 82% of penetrating injuries were treated operatively. Penetrating thoracic injuries are also often associated with other injuries. Inci and colleagues[10] found, in a series of 755 trauma patients, 190 cases with hemothorax, 184 cases with hemopneumothorax, 144 cases with pneumothorax, and nearly 150 patients with rupture of the diaphragm or other injuries.

Mechanisms of Noniatrogenic Tracheobronchial Injury and Pathology

The bronchial tree and the lower two-thirds of the trachea have good bony protection, whereas the cervical trachea is exposed anteriorly. Therefore, lesions of the cervical trachea occur after sharp or blunt trauma to the anterior or lateral aspect or hyperextension of the neck.[5] Injuries of the thoracic trachea or main bronchi resulting from blunt trauma might be explained by 3 models[11]:

- A sudden increase in the airway pressure when the glottis is closed may lead to tracheal perforation or rupture of the main bronchi. This mechanism may explain TBI after blunt abdominal injury with sudden displacement of the diaphragm.
- Extensive anteroposterior chest compression forcing the lungs apart laterally and causing distention and rupture of central airway structures near the carina.
- Rapid deceleration with shearing force applied to the fixed portions of the trachea at the junctions to the cricoid or the carina may cause rupture of the mobile portions of the trachea.

Blunt TBIs are associated with major accompanying injuries in 40% to 100% of cases, primarily involving orthopedic, facial, pulmonary, and intraabdominal injuries, which may be the primary determinant in patient outcome.[8,12] Stab wounds or gunshot wounds of the lower trachea or carina are almost absent in hospitals because they may be associated with fatal injuries of the heart or great vessels and would never arrive in trauma centers for resuscitation.[12] Major accompanying injuries, mainly of the esophagus and great vessels, were reported for in 50% to 80% of penetrating TBIs.[12]

Diagnostics

The diagnosis of TBI can be missed initially, especially in patients with other organ injuries.[13,14] Clinical signs of TBI are listed in **Box 1**. Tachypnea and subcutaneous emphysema are the most common. If TBI is suspected, chest roentgenogram is the first step in diagnosis. Pneumothorax and pneumomediastinum are common in patients with intrathoracic rather than cervical tracheal injuries.[15] Other possible injuries associated with TBIs are listed in **Box 2**. Occasionally, complete or near-complete transection of major bronchi results in the "fallen lung" sign on chest radiographs, which refers to the collapsed lung in a dependent position, hanging on the hilum only by its vascular attachments. Placement of a tube thoracostomy