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Original Article

Outcome Analysis of Tracheobronchial Injuries at a Large Service Hospital

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Abstract

Background: Tracheobronchial injuries, although uncommon, are potentially fatal injuries consequent to both blunt and penetrating neck and chest trauma. Majority of the patients die at the scene before reaching definitive care centers. Moreover, the diagnosis and treatment of these unusual injuries is often missed or delayed, resulting in a significant number of preventable deaths or marked morbidity.

Methodology: All patients with tracheobronchialinjuries presenting at a large service hospital in New Delhi between January 2014 and December 2018 were studied prospectively to determine the current pattern, presentation, and associated injuries along with modalities for diagnosis, treatment, and outcome of these injuries. Only those patients with tracheobronchial injuries who were alive at presentation and consented to be a part of the study were included in the study. Results were analyzed with the currently available literature on the subject.

Results: A total of 52 patients were enrolled for the study during the above-mentioned duration. Injuries were consequent to both blunt and penetrating trauma in almost equal proportions. The most common presentation was found to be surgical emphysema in 21 patients. The injurywas detected within 3 cm of the carina in 65% of the patients with blunt tracheal trauma, whereas cervical trachea was injured in majority (81%) of the penetrating injuries of the neck. Theproximity of the injury to the carina had no detectable effecton mortality. Overall, mortality from tracheobronchial injury was 17%, mainly consequent to multiple neck or chest traumas or other significant associated injuries.

Conclusion: To the best of our knowledge, this study represents one of the most comprehensive cohorts of patients with tracheobronchial injuries evaluated and managed at a service hospital till date. These injuries are potentially life threatening and warrant quick assessment and management. The associated morbidity and mortality continue to be significant enough to highlight the importance of high index of suspicion, early detection, and appropriate management of these serious and often missed injuries.

Key words: Carina, Pneumothorax, Tracheobronchial injury

INTRODUCTION

Injury to the trachea or either of the mainstem bronchus is an unusual and potentially fatal condition which is often overlooked on initial assessment. Although 15–25% of all trauma deaths are due to thoracic trauma, little information is available concerning theincidence of injuries specifically to the trachea or the bronchus as a result of neck or chest trauma. It has been reported that tracheal injury occurs in <1% of trauma patients.[1,2] This may be attributed to the fact that as high as 80–90% of the patients with tracheobronchial injuries go unreported as they die before arriving at any medical facility.[3,4] Trachea is most commonly injured either in the cervical portion or within 2.5 cm of the carina[5] following blunt trauma, whereas penetrating injuries can occur anywhere along the course of the trachea or bronchi. Despite the change in the mechanism of injury, the nature of injuries encountered has remained essentially the same. The immediate effect may include death from asphyxiation, whereas lack of recognition or incorrect management may result in life threatening or disabling airway stricture, bronchopleural fistula, pneumonitis, and acute respiratory distress syndrome (ARDS). Although the awareness of existence of such uncommon and lethal

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injuries has increased over the past few decades, delayed recognition of this injury is not uncommon even today.

PATIENTS AND METHODS

This was a prospective observational study over a period of 4 years beginning January 2014, conducted at a large service hospital at New Delhi. All patients with tracheobronchial injuries admitted during the study period at this center were included in the study. All those subjects who were dead on arrival and those who did not give consent were excluded from the study. A thorough review of the literature related to these injuries was carried out. This included all reports listed in Medline and PubMed (using key words: Trachea, bronchus, tracheobronchial injury, bronchopleural fistula, and chest injury) as well as all other cases that could be identified from listed references in published articles on the subject. Collected information included mechanism of injury, time until diagnosis and treatment, anatomic location of injury, method of diagnosis, type of treatment, and the final outcome. Outcome was reported as survival or death during hospital stay or within 30 days of discharge.

Statistics

Statistical analysis of the data collected was done using descriptive statistics such as mean, median, and mode and multivariate analysis for study of outcome. Quantitative data were analyzed using Student's *t*-test. Qualitative data were analyzed using Chi-square test. Confidence interval of 95% with $P < 0.05$ was taken as statistically significant. Associations between death from tracheobronchial injury and injury location, treatment, and mechanism of injury were assessed using an ordinary χ^2 statistic. To explore the relationship between the variables in a manner that controls for confounding, we fit a multivariable logistic regression model using death from trachea bronchial injury as the outcome. SPSS Version 17 was used for analysis of data.

RESULTS

A total of 1550 patients presented with neck and chest trauma at our hospital during the study period, out of which tracheobronchial injury was present in 52 (3.3%) patients. Complete tracheobronchial transaction was present in 13 (25%) patients (12 tracheal and 1 bronchial) while partial transaction or rent in the tracheal or bronchial wall was present in 39 (75%) cases (37 tracheal and 2 bronchial). 32 (62%) cases were brought directly to our trauma center while 20 (38%) were referred from various other smaller hospitals. Mechanism of injury was blunt trauma in 25 (48%) and penetrating trauma in 27 (52%) patients. Tracheobronchial injury was present in 30 (58%) patients of isolated neck and chest trauma and in 22 (42%) patients with polytrauma. The predominant mode of injury [Figure 1] was found to be vehicular accidents in 21 (41%) patients, wherein pedestrians were involved in 12 cases, while 5 were four-wheeler related and another 4 were two-wheeler related.

Airway was threatened and needed emergent tracheal tube placement in 40 cases either through the wound in trachea in 6 of the 13 cases of complete tracheal transaction or by conventional endotracheal intubation in the remaining 32 cases. 12 patients with a rent in trachea had a patent airway. These injuries were associated with polytrauma or presented as single or multiple neck or chest injuries, most commonly, subcutaneous emphysema in 40% of the patients [Figure 2]. 38 (73%) patients underwent surgical repair of the tracheal injury with tracheostomy in 32 of them, two underwent pneumonectomy for bronchial and other hilar injuries and another one with partial bronchial tear and extensive lung lacerations was managed with bronchial repair and lobectomy. The remaining 11 (21%) cases were managed non-operatively [Figure 3], out of which bronchoscopic-guided tissue glue repair was carried out in two patients.

Intensive Care Unit management was required in 26 (50%) patients. The mean hospital stay was 10.05±8.27 days with a median of 8 days (range - 4–19 days). 43 patients survived and were discharged in a stable condition while nine patients died either in emergency department (ED) or during the course of treatment.

DISCUSSION

The true incidence of tracheal and bronchial injury is difficult to establish, but it has been estimated that only 0.5% of all patients with multiple injuries managed in modern trauma centers suffer from tracheobronchial injury.[5] The vast majority of these injuries is found within 2.5 cm of the carina and is associated with a high mortality due to difficulty in ventilation and maintenance of adequate oxygenation combined with delay in diagnosis.[3,6] Most injuries related to blunt trauma involve the intrathoracic trachea and mainstem bronchi, with only 4% of these injuries reported in the cervical trachea.[4] In penetrating injuries, the cervical trachea is involved in up to 75–80% cases. These injuries are rarely isolated. The associated injuries, especially to the great vessels, coupled with delay in early recognition and prompt intervention, usually results in fatality.

The incidence of tracheobronchial injuries in our series was 3.3% of all neck and chest trauma, mainly as a consequence of right to information, whereas self-inflicted cut throat injuries mainly involved the cervical trachea with exposed

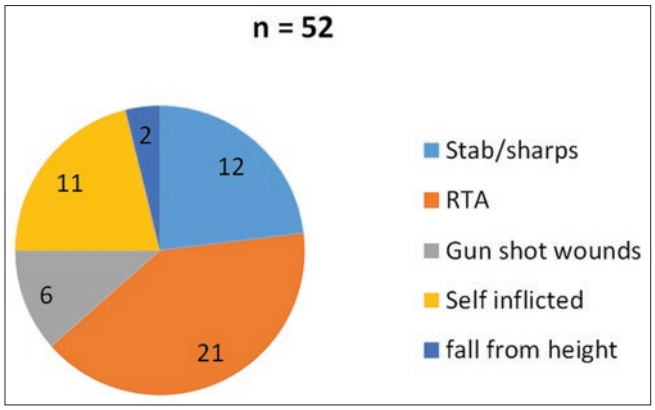

Figure 1: Modes of injury

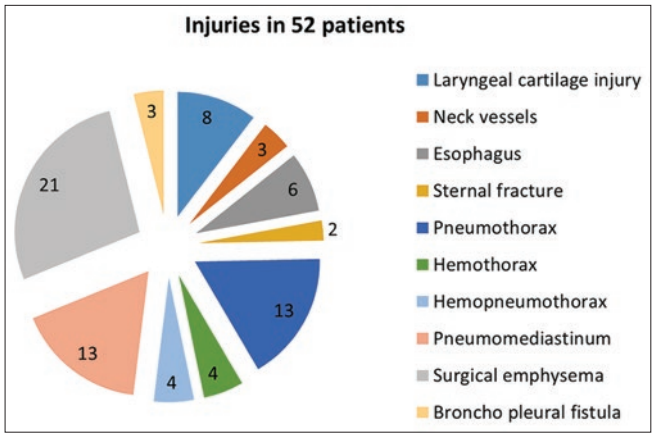

Figure 2: Associated isolated or multiple neck or chest injuries

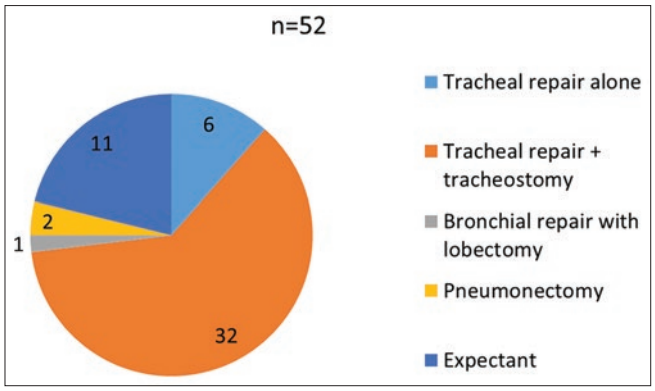

Figure 3: Surgical procedures

airway. Blunt trauma was mainly associated with injury to the intrathoracic trachea, bronchial or parenchymal injuries. All penetrating injuries were explored and major airway injuries were repaired along with repair of other associated injured structures [Figure 4]. Five cases of blunt tracheal injuries were missed on initial ED evaluation but were subsequently picked up either during secondary or tertiary survey. None of the isolated tracheal injury resulted in any fatality. It was rather other neck or chest injuries, mainly major vascular, esophageal, cervical spine, cardiac, or lung injuries including ARDS and hemorrhagic shock which resulted in death in 6 of the 9 cases that included two of the three bronchial injury cases who did not survive. The cause of death in the remaining three was severe traumatic brain injury, coagulopathy consequent to Grade 5 liver trauma and sepsis as a result of bowel injury with pelvic fracture.

The most important reason for delay in diagnosis for these injuries is their subtle presentation. At times, the only presentation is gradually increasing subcutaneous emphysema or a persistent air leak in the underwater seal drain for chest tube. Dyspnea and respiratory distress are frequent symptoms, occurring in 76–100% of patients.[7-9] The other common symptom is hoarseness or dysphonia, which occurred in 46% of the patients in a series published by Reece and Shatney.[10] Deep cervical emphysema and pneumomediastinum are seen in 60% and pneumothorax occurs in 70% of patients with tracheobronchial injuries.[11,12]

Occasionally, complete or near-complete transaction of mainstem bronchus results in the "absent hilum" or "fallen lung" sign of Kumpe on chest radiographs [Figure 5]. Contrast-enhanced computed tomography (CT) may show pneumomediastinum. In fact, the presence of this ominous finding should prompt us to look for tracheal or esophageal injury. CT scan may also show disruption in the continuity of the tracheobronchial air column [Figure 6]. Flexible bronchoscopy has proved to be an important diagnostic as well as an occasional therapeutic tool in the management of these injuries and should be performed in all the patients with suspected tracheobronchial injury after initial resuscitation and stabilization.[13,14] It can delineate the site and extent of injuries but at the same time, it may create larger defects and very small defects may go unnoticed if it is done by an unexperienced person. Therapeutic utility of bronchoscopy lies in sealing small, mainly blunt trauma defects of the major airways with glue or a sealing agent. Patients with small injuries without appreciable air leaks can be treated non-operatively; however, most patients with larger defect and significant air leak require urgent repair. Surgical management is dictated by the extent, location and size of the injury, amount and pattern of air leak, and the presence of associated injuries.[15] Delay or lack of recognition is common, and subsequent complications of stenosis and obstruction are the rule in missed tracheobronchial injuries.

In a review of 1178 trauma autopsy reports, only 33 patients (2.8%) of tracheobronchial rupture were identified and 81% of these patients died before reaching the hospital.[16] Another study of 585 patients who died from motor vehicle accidents over a 10-year period identified only 5 patients with tracheobronchial injuries, or <1%.[17] Four of these five patients died at the scene. In 1873, Seuvre[17] describeda 74-year-old woman with the right main bronchus avulsion discovered at autopsy. In 1931, Nissen[18] described a successful

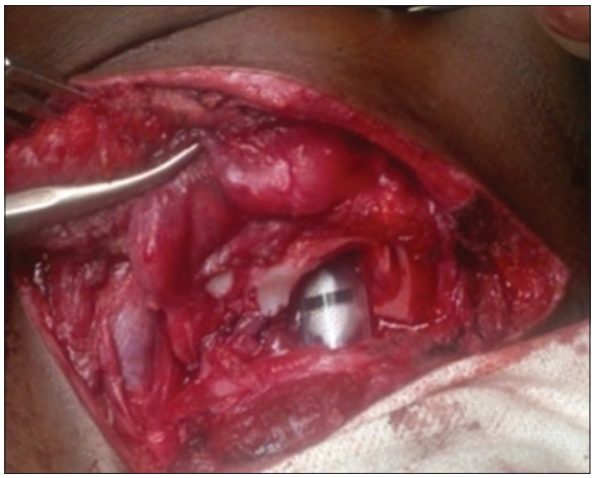

Figure 4: Tracheal injury with endotracheal tube *in situ*

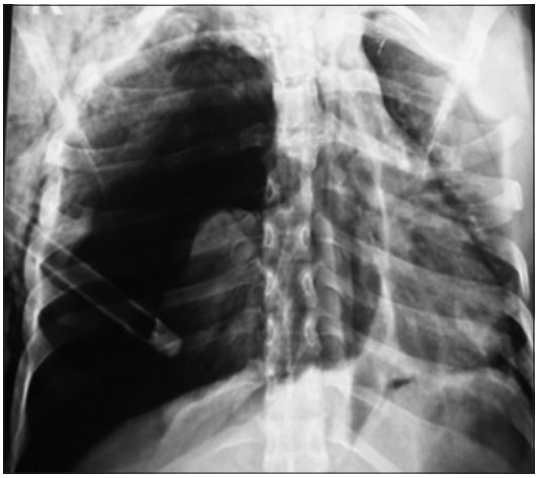

Figure 5: Chest radiograph showing the right bronchial injury with lung collapse and tension pneumothorax - Fallen lung sign

pneumonectomyin a 12-year-old girl with a post-traumatic stricture of the left main bronchus. Later, in 1949, Griffith[19] reported a patient with primary sleeve resection and repair of a post-traumatic stricture of the left main bronchus.

Various theories have been suggested regarding mechanism of injury to the tracheobronchial tree.[20,21] One theory associates tracheobronchial disruption with a sudden, forceful compression of the chest wall, decreasing its anteroposterior diameter, and pulling lungs apart at the carina. This may be the likely mechanism involved in crush injuries. Another theory suggests compression of the chest and trachea on a closed glottis increasing the airway pressure, leading to rupture of the airway at the membranous portion, which has been demonstrated experimentally in a canine model.[20,21] The most logical third theory is applicable in blunt trauma consequent to rapid deceleration, producing shearing force, such as the one experienced in motor vehicle crash, causing rupture of the trachea and bronchi.

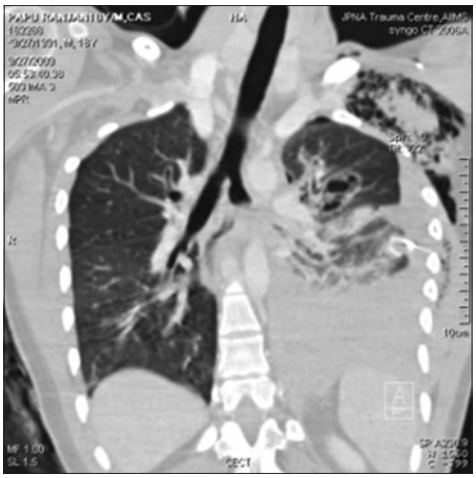

Figure 6: Left mainstem bronchus injury seen on coronal section of computed tomography chest

Although some investigators have found equal frequency of the right-sided and left-sided injuries,[22,23] others also have noticed an increased frequency of the right mainstem injuries.[4,18] In our study, out of three bronchial injuries, two were on the right side and one was on the left side [Figure 7]. The acuity of the presentation of a patient with a right-sided injury may be related to a higher incidence of associated injuries.

Some authors have suggested that the high early mortality in blunt tracheobronchial trauma is from other associated injuries.[16,24] For patients with blunt tracheobronchial injuries, Jones *et al*.[25] reported an average of five associated injuries in patients who died compared with three associated injuries in patients who survived. The survivors experienced less severe injuries such as bony fractures and closed head injuries.[25] The increased early mortality appears to result from coexisting fatal injuries and not necessarily the tracheobronchial injury. During our study period, nine patients died consequent to either multiple (>3) neck or chest injuries or other associated significant injuries with a median ISS of 22 (range 16–34).

Tracheobronchial injuries are not diagnosed immediately in 25–68% of patients.[26,27] Taskinen *et al*.[28] described a surrounding layer of peribronchial tissue, especially on the left, which may be adequate to allow continued ventilation past an area of bronchial injury. However, in 2–6 weeks, the bronchus can become obstructed by granulation tissue, preventing air exchange. Those bronchi that do not completely obstruct but remain stenotic tend to develop post-obstructive pneumonia and bronchiectasis. This development usually leads to non-functional lung tissue distal to the area of stenosis, even if the airway is restored. However, when the airway is completely obstructed, the distal lung is often filled with mucus and protected

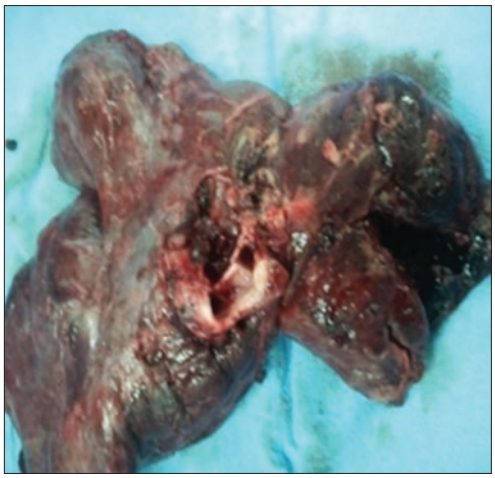

Figure 7: Extensive bronchial and parenchymal lung injury seen on pneumonectomy specimen

from infection.[29] Experimentally occluded bronchi for 5–7 months can be repaired and reairated with return of physiological functions. Patients with chronic but complete bronchial obstruction do not have parenchymal destruction but instead, maintain functional pulmonary tissue beyond the point of obstruction.[4,30]

Chest radiography is the standard initial imaging modality for evaluation of all chest injuries including tracheobronchial injury, but CT is preferred if a tracheobronchial tear is suspected.[31] Apart from imaging, a suspected airway injury should undergo fiberoptic bronchoscopy for detection and localization of the injury. Both surgical incision and intraoperative ventilation are dictated by the location of the injury and the surgical approach. Surgical debridement of the area of acute injury and excision of scarred, narrowed segments of chronic tracheobronchial injuries should be performed to create healthy edges that can be repaired successfully. Often the airway distal to the chronic obstruction will be filled with mucus, which must be removed to allow adequate ventilation of the atelectatic segment. The choice of suture material is absorbable suture. In our study, we used 3-0 polydioxanone interrupted sutures. Follow-up bronchoscopy to evaluate the airway anastomosis is recommended at 1–2 weeks following surgery.

Summary

Road traffic accidents with high-speed deceleration have become more common over the past few decades and have accounted for majority of the life-threatening tracheobronchial injuries occurring today. Both deceleration and crush injuries occur near the carina and most commonly involve the distal 3 cm of trachea or right main bronchus. Penetrating injuries involve proximal trachea more often than distal trachea and bronchi. The significant mortality rate appears to be related to coexisting injuries rather than the tracheobronchial injury per se. Immediate recognition of these injuries is often difficult and is based on the mechanism of injury, and a high index of suspicion should be exercised to diagnose these potentially fatal injuries. Instead of an acute presentation with a large air leak, tracheobronchial injuries may often run an indolent course involving retained secretions, poor lung expansion, residual or recurrent pneumothorax, and eventually high-grade bronchial obstruc

Our experience has been mainly in treating both blunt and penetrating tracheal injuries. Although early diagnosis is becoming more common now, a significant delay is still seen in a large number of patients even today. This study supports active search and early repair of these injuries to prevent potential pulmonary complications and long-term morbidity associated with missed tracheobronchial injuries.

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