

Injuries to the tracheobronchial tree in closed trauma

WALTER AMAUCHI, DARIO BIROLINI, PAULO D BRANCO, MARIO RAMOS DE OLIVEIRA

From the Service of Surgical Emergency, Hospital das Clínicas, University of São Paulo School of Medicine, São Paulo, Brasil

ABSTRACT Seven cases of injury to the tracheobronchial tree in closed trauma of the thorax, treated by the surgical emergency service of the Hospital das Clínicas, University of São Paulo School of Medicine, during the period 1980-2 are described and compared with previously published cases. The diagnosis of the seven cases presented in this series was clinically suspected and endoscopically confirmed within 24 hours of injury, all patients being immediately submitted to reconstructive surgery; and except for one who failed to respond to initial resuscitation and died during surgery all the patients had a satisfactory postoperative course. Many previously reported cases of tracheobronchial injury by contrast have taken more than a month to be diagnosed; but for the best results such injuries must be repaired immediately. Awareness of the possibility of tracheobronchial injury in cases of violent chest trauma is important for early diagnosis; emphysema, dyspnoea, and pneumothorax are not always present, and absence of radiological and clinical signs of tracheobronchial injury does not exclude such injury. Bronchoscopy is the most important investigation for clinical diagnosis. Once the diagnosis has been made thoracotomy is nearly always required. Throughout the surgical procedure expert cooperation between anaesthetist and surgeon is essential. After operation prevention of further damage to the trachea depends on careful respiratory management.

Damage to the tracheobronchial tree associated with closed chest injuries is a severe type of trauma,¹ which has considerably increased in incidence in recent years. Schomberg in 1912 was one of the first to report this type of injury,² which was then considered fatal. In 1927 Krinitzki observed complete atelectasis of the right lung at necropsy in a patient who had suffered chest injury 21 years previously.³ The first successful correction of traumatic bronchial rupture, eight months after the event, was by Griffith in 1949.³

To determine the incidence of such injuries precisely is difficult as an appreciable number remain undiagnosed. In a study of 98 patients reported by Hood and Sloan⁴ 70% of the injuries were diagnosed after 24 hours and over 40% one month after trauma. On examining 10 papers published during 1949-80, which included 20 cases of tracheobronchial rupture, we noted that in 10 of these the diag-

nosis was made at least one month after trauma, clearly demonstrating that late detection of such injuries is still common.²⁻¹¹

The purpose of this paper is to present a series of seven patients (six male and one female) with traumatic rupture of the trachea or major bronchi or both treated at the emergency unit of the Hospital das Clínicas during 1980-2, with special emphasis on data which may be useful for early diagnosis. In tables 1-3 the basic data relating to these patients are compared with data on 20 cases reported in published papers.³

Table 1 *Age and sex distribution of patients with closed tracheobronchial rupture*

Age (y) and sex	Present series	Previous authors ²⁻¹¹
All	7	20
0-10	3	1
11-20	0	4
21-30	2	9
31-40	1	4
Over 40	1	1
M:F	6:1	16:4

Address for reprint requests: Dr D Birolini, Rua Olegario Mariano 671, 05612-São Paulo, Brasil.

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Table 2 *Closed tracheobronchial rupture: interval between diagnosis and surgery*

	<i>Present series</i>	<i>Previous authors²⁻¹¹</i>
Less than 24 hours	7	10
Over 1 month	0	10
Total	7	20

Case reports

CASE 1

A 45 year old white man was injured in a car accident on 19 June 1980. On admission to hospital the patient was conscious and slightly dyspnoeic but with no signs of shock. There was subcutaneous emphysema of the head, neck, and chest and a penetrating wound of the right eye. There were no limb injuries. Radiography of the thorax showed mediastinal and cervical emphysema and bronchoscopy showed a longitudinal rupture of the membranous portion of the trachea 4 cm long, adjacent to the carina.

A right thoracotomy was performed through the fourth intercostal space and the injury was repaired with interrupted 3/0 monofilament nylon sutures. At the same time cricothyroidostomy was performed for mechanical ventilation. This was required for only one day and the patient was discharged from hospital having made an uneventful recovery on the 16th postoperative day. At follow up 11 months after operation he had no complaints and had resumed normal activities.

CASE 2

A 32 year old white man was injured in a landslide on 29 August 1980. On admission he was conscious and dyspnoeic but with no signs of shock. There was subcutaneous emphysema of the head, neck, and chest and superficial abrasions, with a fracture of the left clavicle. There were no limb injuries.

Table 3 *Closed tracheobronchial rupture: distribution of site of injury*

	<i>Present series</i>	<i>Previous authors²⁻¹¹</i>
Trachea	3	4
Right major bronchus (RMB)	0	7
Left major bronchus (LMB)	0	7
Trachea and RMB	3	2
Trachea and LMB	0	0
Trachea, RMB, and LMB	1	0
Total	7	20

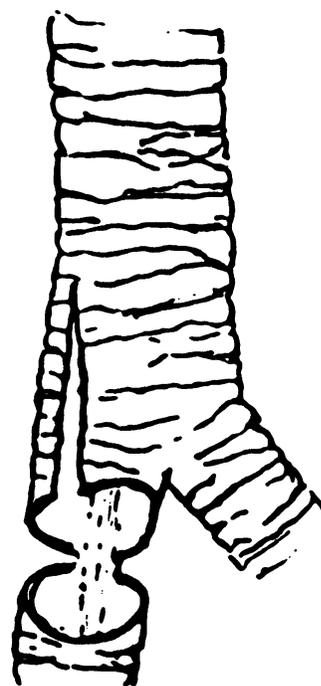


Fig 1 *Case 1: Circular rupture of the right main bronchus at its origin and longitudinal tear of the right anterolateral aspect of the distal trachea.*

A chest radiograph showed mediastinal and cervical emphysema, a right sided pneumothorax, multiple right sided rib fractures, and a fracture of the left clavicle. A right sided intercostal tube was inserted and bronchoscopy was performed, which showed a rupture of both the trachea and the right main bronchus adjacent to the carina.

A right thoracotomy through the fourth space was performed; this showed a complex injury with circular rupture of the right main bronchus at its origin and a 4 cm longitudinal tear of the right anterolateral aspect of the distal trachea (fig 1). This was repaired with interrupted 4/0 monofilament nylon sutures and cricothyroidostomy was performed in view of the multiple depressed fractures of the rib cage.

Ventilatory assistance was required for four days and the tracheostomy tube was removed on the eighth day. The patient made an uneventful recovery and was discharged from hospital on the 14th day. Bronchoscopy four months after repair showed neither stenosis nor granulation formation. At the follow up 10 months after operation the patient had no complaints and had resumed normal activities.

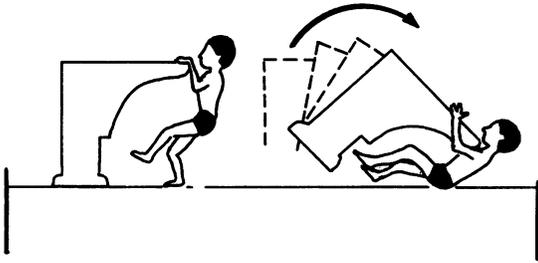


Fig 2 Case 3: Mechanism of the injury producing ruptures of the trachea and right main bronchus.

CASE 3

A 3 year old mulatto boy was admitted after a cement washtub accident on 21 December 1980. The mechanism of injury is shown in figure 2. On examination he was conscious and dyspnoeic but with no signs of shock. There was subcutaneous emphysema of the face, neck, and thorax, with diminished breath sounds bilaterally but no cardiac abnormality and no evidence of injury to the abdomen or limbs. A chest radiograph showed mediastinal and cervical emphysema with a right tension

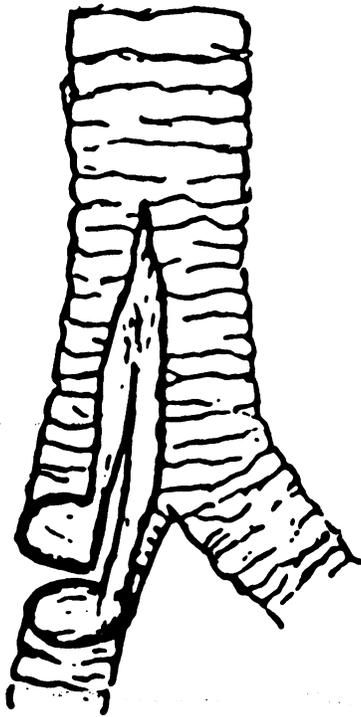


Fig 3 Case 3: Circular rupture of right main bronchus.

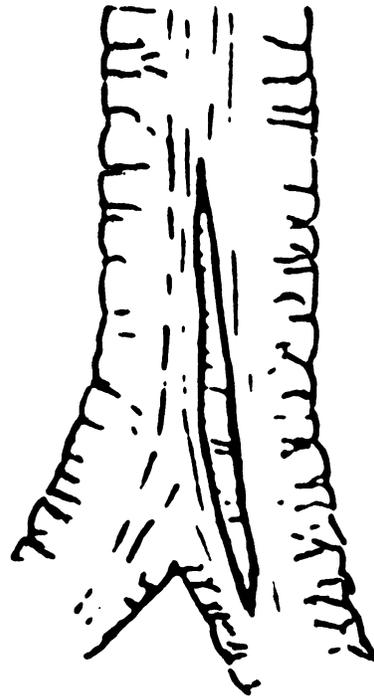


Fig 4 Case 5: Longitudinal tear of the membranous portion of the trachea extending into the origin of the right main bronchus.

pneumothorax and mediastinal shift to the left. A right intercostal tube was inserted and bronchoscopy was performed; this showed a rupture of the right main bronchus.

Operation through a right thoracotomy in the fourth space showed a complex injury with longitudinal ruptures of both the anterior and the posterior walls of the trachea measuring 4 cm, together with a circular rupture of the right main bronchus, where only part of the membranous portion was spared (fig 3). Reconstruction was performed with interrupted 5/0 monofilament nylon sutures, but without tracheostomy. After operation the patient made an uneventful recovery and was discharged on the eighth postoperative day. When seen six months after operation he was well with no clinical abnormality.

CASE 4

A 30 year old white woman was admitted after being run over by a vehicle on 28 March 1981. On admission she was unconscious, pale, and shocked, with an unrecordable blood pressure. There were facial abrasions and generalised emphysema of the

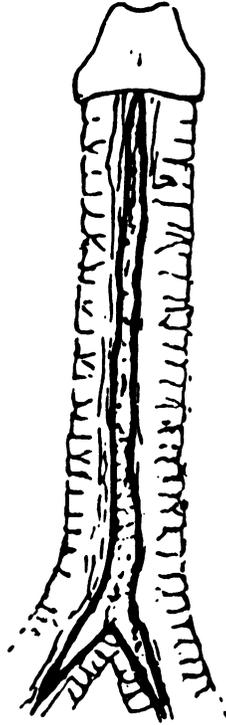


Fig 5 Case 6: Extensive tear of the membranous portion of the whole trachea extending into both major bronchi.

head, neck and thorax. There was paradoxical movement of the chest wall and reduced breath sounds. There was evidence of fluid in the abdomen and fractures of the left humerus and both femora. Immediate bilateral chest drainage showed bilateral bronchopleural fistulas, which virtually prevented ventilation.

After orotracheal intubation and intravenous infusion the patient was taken to the operating theatre, where a bilateral anterolateral thoracotomy showed a rupture of the right main bronchus extending towards the trachea. Before repair could be undertaken the patient sustained a cardiac arrest and could not be resuscitated. The abdominal injuries were later found to include rupture of the liver and spleen.

CASE 5

A 5 year old white boy was admitted after a cement washtub accident on 8 May 1981. On examination he was conscious and dyspnoeic but with no signs of shock. There was rapidly progressive emphysema of the face, neck, and thorax and paradoxical move-

ment of the sternum. Breath sounds were normal and there was no cardiac abnormality and no injury to the abdomen or limbs. A chest radiograph revealed mediastinal and cervical emphysema and a right sided mediastinal haematoma, but no pneumothorax. Bronchoscopy showed a rupture of the trachea.

Operation through a right thoracotomy in the fourth space showed a 3.5 cm longitudinal tear of the membranous portion of the trachea extending into the origin of the right main bronchus (fig 4). This was repaired with interrupted 5/0 monofilament nylon sutures. Tracheostomy was not performed. The patient made an uneventful recovery and was discharged on the ninth postoperative day. When he was subsequently seen there were no clinical abnormalities.

CASE 6

A 4 year old mulatto boy was admitted after a cement washtub accident on 27 September 1982. Before admission bilateral drainage of the chest for pneumothorax had been performed at another hospital. On arrival he was conscious and dyspnoeic but with no signs of shock. There was subcutaneous emphysema of the face, neck, and abdomen, with diminished breath sounds but no other abnormalities. A chest radiograph confirmed extensive emphysema of the neck and mediastinum and endoscopy showed rupture of the trachea adjacent to the carina.

In view of increasing dyspnoea and emphysema the patient was transferred to the operating theatre, where a right thoracotomy through the fourth space revealed an extensive tear of the membranous portion of the whole of the trachea extending into both major bronchi (fig 5). Repair was performed with 5/0 monofilament nylon sutures, access to the cervical portion of the trachea being obtained through a separate right sided cervical incision, when the injury was found to extend up to the level of the cricoid cartilage.

After operation the patient developed respiratory failure and right sided bronchopneumonia with retained secretions. Intubation and mechanical ventilation were therefore maintained until the fifth postoperative day, when tracheostomy was performed. Ventilation was discontinued on the seventh postoperative day and the tracheostomy was removed on the 15th day. He was discharged on the 20th day after operation.

CASE 7

A 28 year old white man was injured in a car accident on 7 October 1982. On physical examination he was conscious and agitated, but breathing nor-

mally and without signs of shock. There were facial abrasions and lacerations and progressive emphysema of the neck but no evidence of injury to the thorax, abdomen, or limbs. Radiography of the neck and thorax showed cervical emphysema extending into the mediastinum, with a depressed fracture of the upper anterior chest on the left side. Bronchoscopy showed injury to the anterior aspect of the subglottic region and impaired movement of the vocal cords.

Emergency operation on the neck showed a complete transection of the trachea at the level of the cricoid cartilage, which was fractured. The injury was treated by débridement and resection of the damaged segment and end to end anastomosis of the trachea, interrupted 5/0 monofilament nylon sutures being used. In view of the cricoid injury a distal tracheostomy was performed through the fifth tracheal cartilage. After operation the patient made an uncomplicated recovery. The tracheostomy was removed and he was discharged from hospital on the 28th postoperative day, by which time endoscopy had confirmed a good tracheal lumen and glottic aperture, though there was decreased mobility of the vocal cords.

Discussion

The tracheobronchial tree is seldom injured in closed trauma of the chest, owing to the effective protection provided by the scapulas, spine, and thoracic cage. When it does occur several mechanisms may be responsible either singly or in combination—namely: (a) acceleration followed by abrupt deceleration; (b) torsion of the tracheobronchial tree; (c) compression between the sternum and the vertebral spine; (d) tension on the tracheobronchial tree near the carina, due to enlargement of the transverse diameter of the thorax during anteroposterior compression³; (e) sudden increase in the intraluminal pressure of the tracheobronchial tree, caused by trauma during full inspiration with the glottis closed.¹²

Most commonly the injury is in the region adjacent to the carina, affecting the trachea or one bronchus or both trachea and bronchus. A review of published reports shows that the incidences of trauma of the left and the right main bronchus are similar, although this was not seen in the present series (table 3). In extent the injuries may vary from simple linear lacerations (figs 4 and 5) to more complex ones (figs 1 and 3) or even complete transection (case 7).

In several cases, particularly where there has been partial rupture, these injuries have been reported to heal spontaneously since the proximal and distal

extremities are held in alignment by the peribronchial vessels and tissue. When an extensive rupture is not repaired the healing process causes stenosis at the site of injury, resulting in atelectasis of the distal lung and obstructive complications such as recurrent pneumonia and bronchiectasis. This occurs particularly in cases which are diagnosed late. Of 20 patients referred to in published reports, 10 were submitted to operative treatment at a late stage, when there was already evidence of constriction of the tracheobronchial lumen (table 2).

The most common associated thoracic injuries are fractures of the ribs, sternum, and clavicle and pulmonary contusion. Rupture of the oesophagus, although rare, should always be considered as it presents a high risk if undiagnosed and untreated, but this association was not found in any of our cases. Haemoptysis and haemothorax occur seldom and are probably due to rupture of the bronchial vessels.⁴

Diagnosis of these injuries depends partly on an awareness of the possibility of tracheobronchial injury in any patient who has experienced violent chest trauma. Clinical signs depend on the site of injury but emphysema and dyspnoea are not always present and haemoptysis was not seen in any of our patients although reported in published cases. Pneumothorax also may not be present when the injury is confined to the mediastinum and has no connection with the pleural cavity, but pneumothorax with a bronchopleural fistula that persists after drainage strongly suggests the diagnosis (case 4).

A plain chest radiograph affords important evidence, although the radiological findings are not pathognomonic. The presence of mediastinal or deep cervical emphysema, whether or not associated with unilateral or bilateral pneumothorax and fractures of the clavicle and first rib, deserves special attention. The absence of radiological and clinical signs of fracture of the thoracic cage does not, however, eliminate the possibility of injury to the tracheobronchial tree, especially in children since they have more flexible bone structures (cases 3, 5, and 6). Bronchoscopy is the most important investigation in clinical diagnosis. Apart from confirming the injury it helps to identify the site and extent of it, which is essential in deciding on treatment. It was used in all patients in this series except one, who was taken to the operating theatre immediately because of her critical condition (case 4). A flexible bronchoscope should be used when there are associated injuries of the head or cervical spine, as these may be aggravated by rigid bronchoscopy. Bronchography has not been used for diagnosis because it may be difficult as a result of the patient's clinical

condition and because adequate information can be obtained by bronchoscopy.

After diagnosis of a tracheobronchial rupture thoracotomy is required except in those cases in which less than one third of the circumference of the trachea and bronchus is disrupted and the lung re-expands fully with chest drainage. A posterolateral thoracotomy through the fourth space is generally used. In ruptures of the trachea and main bronchi adjacent to the carina the approach should be through the right side, while in ruptures of the distal left main bronchus it should be through the left.³

When the chest has been opened the mediastinal pleura is opened and the injury exposed. On the right this is assisted by ligation and division of the azygos vein. When the site of injury is exposed the air leak often increases and may interfere with ventilation. An endotracheal tube is therefore passed beyond the site of rupture under direct vision. When the injury affects only one of the main bronchi ventilation is maintained through intubation of the contralateral bronchus. When ventilation is under control the injury is assessed and repaired with interrupted one layer 5/0 or 4/0 monofilament nylon sutures with the knots tied on the outside. The repair is reinforced by adjacent tissues and tested for air leaks before closure of the chest.

Throughout the procedure it is essential to have expert cooperation between the anaesthetist and the surgeon, as regards both the positioning of the tube for ventilation and the use of small volume and high frequency ventilation to minimise the air leak from the site of injury. The role of tracheostomy as a routine procedure in the management of these injuries is controversial. It has been recommended by Urschel¹² to reduce the intraluminal pressure in the trachea by eliminating glottic closure. On the other hand, Lawhorne⁸ considers it an unnecessary procedure. It was used early in three of our patients (cases 1, 2 and 7) and at a late stage in a fourth (case 6). In the other two surviving patients tracheostomy was not used and both had an eventful postoperative course with a satisfactory result. We therefore believe that tracheostomy is not required routinely and should be performed only in specific circumstances.

In the case of late diagnosis a full study of the affected lung is essential as treatment may range

from bronchoplasty to pneumonectomy, according to the degree of damage to the lung parenchyma. It is important to remember, however, that investigations may be misleading owing either to stenosis or atelectasis or to lung secretions and a final decision about whether resection is required can be made only at operation.

The best results are obtained when these injuries are repaired immediately after trauma as this avoids lung damage from subsequent scarring and technical difficulties resulting from fibrosis of the lung hilum. Endoscopic dilatation has been used in the management of late stenosis^{4, 6, 9} but cannot be relied on to produce a satisfactory result.

After surgical repair respiratory care is critical for preventing further damage to the trachea by prolonged tracheal intubation and mechanical ventilation.

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