ORIGINAL ARTICLES

Medical and Surgical Management of Noniatrogenic Traumatic Tracheobronchial Injuries

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OBJECTIVE: To describe the medical and surgical management of noniatrogenic traumatic tracheobronchial injuries.

PATIENTS AND METHODS: From January 1993 to July 2004, 15 cases of traumatic tracheobronchial injury were treated in our department. The diagnosis was established by bronchoscopy and a computed tomography chest scan was performed on all patients. Surgical treatment was selected for patients with unstable vital signs, an open tracheal wound, associated esophageal lesions, progression of subcutaneous or mediastinal emphysema, mediastinitis or suspicious mediastinal secretions on imaging tests, or difficulties with mechanical ventilation due to the traumatic tracheobronchial injury.

RESULTS: The mean (SD) age of the patients was 35.5 (18.9) years and 12 (80%) were male. Of the 15 cases, 13 (86.7%) had penetrating trauma and 2 (13.3%) blunt trauma. The most common location of the injury was in the bronchi (9 cases; 60%), followed by the cervical trachea (4 cases; 26.6%), followed by both the thoracic trachea and bronchi (2 cases; 13.4%). The most common initial symptom was subcutaneous emphysema, which presented in 11 (73.3%) patients. Chest (12 cases; 86.7%) and orthopedic injuries (9 cases; 60%) were the most common associated injuries. Surgery was the treatment of choice in 11 (73.3%) cases and conservative medical treatment in 4 (26.7%). An irreversible brain injury caused the death of 1 patient receiving conservative treatment.

CONCLUSIONS: Tracheobronchial injuries may be treated conservatively if they meet strict selection criteria. Size and location should not be used as selection criteria for surgical treatment.

Key words: *Tracheobronchial injuries. Trauma. Bronchial rupture. Subcutaneous emphysema. Bronchoscopy. Thoracotomy.*

Manejo médico-quirúrgico de las lesiones traqueobronquiales traumáticas no iatrogénicas

OBJETIVO: Describir el manejo médico-quirúrgico de las lesiones traqueobronquiales traumáticas no iatrogénicas.

PACIENTES Y MÉTODO: De enero de 1993 a julio de 2004 se registraron en nuestro servicio 15 casos de lesiones traqueobronquiales traumáticas. En todos los pacientes el diagnóstico se estableció por broncoscopia y a todos se le realizó una tomografía computarizada de tórax. Se eligió tratamiento quirúrgico cuando había inestabilidad vital del paciente, herida traqueal abierta, lesiones esofágicas asociadas, progresión de enfisema subcutáneo o mediastínico, mediastinitis o colecciones mediastínicas sospechosas en pruebas de imagen o dificultades en la ventilación mecánica por la lesión traqueobronquial traumática.

RESULTADOS: La edad media (± desviación estándar) de los pacientes fue de 35,5 ± 18,9 años y 12 (80%) eran varones. Se registraron 13 traumatismos cerrados (86,7%) y 2 abiertos (13,3%). La localización más frecuente de la lesión fue bronquial (9 casos; 60%), seguida de tráquea cervical (4 casos; 26,6%) y tráquea toracicobronquial (2 casos; 13,4%). El síntoma inicial más frecuente fue el enfisema subcutáneo, que presentaron 11 pacientes (73,3%). Las lesiones asociadas más frecuentes fueron torácicas, con 12 casos (86,7%), seguidas de ortopédicas, con 9 (60%). El tratamiento de elección fue quirúrgico en 11 casos (73,3%) y médico conservador en 4 (26,7%). Falleció una paciente tratada de forma conservadora por lesión cerebral irreversible.

CONCLUSIONES: Las lesiones traqueobronquiales pueden tratarse de forma conservadora si cumplen criterios estrictos de selección. El tamaño o la localización no debe ser un criterio para la elección del tratamiento quirúrgico.

Palabras clave: *Lesiones traqueobronquiales. Traumatismo. Rotura bronquial. Enfisema subcutáneo. Broncoscopia. Toracotomía.*

Introduction

The incidence of traumatic tracheobronchial injury has been rising in recent decades, largely because of an increase in traffic accidents and the growing use of general anesthesia with orotracheal intubation in older patients.[1] Most noniatrogenic traumatic injuries are the result of high-energy blunt trauma, such as those caused by traffic accidents and falls. Nevertheless, the incidence of noniatrogenic injuries following intubation and tracheotomy is increasing.[2] Despite improvements in emergency transportation services, more than 30% of patients with a traumatic tracheobronchial injury die before reaching the hospital.[3] The overall incidence of these types of injuries is approximately 1% to 2% of

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high-energy accidents,[4,5] and with only a few cases occurring each year, opportunities to train health care professionals to manage them are scarce.[6,7]

This study describes the surgical and medical approaches to the treatment of noniatrogenic traumatic tracheobronchial injuries and the indications for selecting one or the other.

Patients and Methods

We retrospectively reviewed the medical records of patients diagnosed with a noniatrogenic traumatic tracheobronchial injury at our hospital from January 1993 to July 2004. Iatrogenic traumatic tracheobronchial injuries —most of which have no associated traumatic injuries—were excluded because the prognosis and management of these injuries are very different from those caused by noniatrogenic injury. All patient characteristics of note were recorded: cause, initial symptoms, location of injury, diagnostic tests performed, associated injuries, treatment, length of hospitalization, and follow up. All patients underwent flexible bronchoscopy and a computed tomography chest scan. In most cases, surgical treatment was selected for those patients with associated esophageal lesions, open tracheal wounds, progression of subcutaneous or mediastinal emphysema, mediastinitis or suspicious mediastinal secretions, difficulties with mechanical ventilation or deterioration of vital signs due to sepsis or acute respiratory distress syndrome. The size of the injury was measured by bronchoscopy. None of the following were considered indications for surgery: early diagnosis, a specific lesion size, bronchial involvement, involvement of the cartilaginous tracheal wall, or the need for mechanical ventilation due to some other cause. Treatment for nonsurgical cases included antibiotics and observation without surgery. Early extubation was attempted in all patients, whether treated conservatively or surgically; if this was not feasible, tube insertion was attempted below the level of the injured area when possible. To avoid weakening the sutures in patients with bronchial injuries, mechanical ventilation—when necessary—was performed at the lowest possible pressure at which the patient's vital signs could be kept stable without selective intubation. In the surgical interventions, biodegradable tracheobronchial sutures were used and lung resection was avoided if possible. In all cases, we used interrupted sutures covered by proximate autologous tissue. For esophageal injuries, primary sutures were used in some cases and esophageal exclusion in others, with reconstruction by coloplasty deferred to a later time. Case 13 required a right pneumonectomy and reconstruction of the tracheal carina because of the size of the injury to the main right bronchus and tracheal carina. Clinical and bronchoscopic follow up of all surviving patients was performed at discharge and after 3, 12, and 24 months.

Descriptive statistical analysis was performed with the SPSS 11.0 Statistical Software Package (SPSS; Chicago, IL, USA).

TABLE 1
Characteristics of Patients and Injuries*

Case	Sex/Age, Years	Type of Trauma	Initial Symptom	Location	Size, cm	Treatment	Result
1	M/47	Penetrating Cervical stab wound	SE	Cervical trachea	3	S	Excellent
2	M/55	Penetrating Sports accident	SE	Cervical trachea	1	S	Excellent
3	F/84	Blunt Accidental direct trauma	SE	Cervical trachea	2	Me	Death
4	F/30	Blunt Traffic accident	SE	Bronchi	2	Me	Excellent
5	M/27	Blunt Traffic accident	SE	Thoracic trachea and bronchi	2	Me	Excellent
6	M/35	Blunt Traffic accident	SE	Cervical trachea	2	S	Excellent
7	M/14	Blunt Traffic accident	P	Bronchi	4	S	Excellent
8	M/48	Blunt Traffic accident	SE	Bronchi	2	S	Excellent
9	M/14	Blunt Crush injury	D	Thoracic trachea and bronchi	6	S	Excellent
10	M/26	Blunt Fall	SE	Bronchi	1	S	Excellent
11	M/28	Blunt Crush injury	SE	Bronchi	1	Me	Excellent
12	M/20	Blunt Traffic accident	P	Bronchi	2	S	Excellent
13	M/17	Blunt Traffic accident	P	Bronchi	2	S	Excellent
14	M/23	Blunt Traffic accident	SE	Bronchi	1	S	Excellent
15	F/20	Blunt Traffic accident	SE	Bronchi	1	S	Excellent

*M indicates male; F, female; SE, subcutaneous emphysema; P, pneumothorax; D, dyspnea; S, surgery; Me, medical.

TABLE 2
Clinical Findings: Preliminary and Most Common Findings From Traumatic Tracheobronchial Injuries

Clinical Finding	Preliminary Finding	General Findings
Subcutaneous emphysema	11 (73.3%)	15 (100%)
Pneumothorax	3 (20%)	10 (66.7%)
Dyspnea	1 (6.7%)	12 (80%)
Mediastinal emphysema	–	14 (93.3%)
Hemoptysis	–	8 (53.3%)
Atelectasis	–	3 (20%)
Hemothorax	–	9 (46.7%)

TABLE 3
Most Common Associated Injuries

Injury	Number, %
Thoracic	12 (80)
Rib fractures	10 (66.6)
Pneumothorax	10 (66.6)
Lung injury	10 (66.6)
Hemothorax	9 (60)
Esophageal injuries	2 (13.3)
Nonthoracic injuries	
Orthopedic injuries	9 (60)
Cranial-encephalic trauma	6 (40)
Maxillofacial	6 (40)
Abdominal	2 (13.3)

Results

A total of 15 patients—12 (80%) males and 3 (20%) females—were evaluated. The mean (SD) age was 35.5 (18.9) years. The cause of the tracheobronchial injury was blunt trauma in 13 (86.7%) cases and penetrating trauma in 2 (13.3%) (Table 1). The mean duration of hospitalization was 17.6 (9.5) days and the mean length of stay in the intensive care unit (ICU) was 12.7 (10.7) days. The mean time to diagnosis was 10.2 (12.1) hours. The most common preliminary findings and those found on follow-up examination are shown in Table 2. Associated injuries are shown in Table 3. Table 4 shows details of the surgical intervention, time to diagnosis, and length of hospitalization. Only 1 conversion from conservative medical treatment to surgery—due to symptom progression—was necessary. The survival rate was 93.3% (14 cases). A tracheal or bronchial repair was performed in 10 cases (66.6%) and 1 tracheal injury was treated by tracheotomy. The death of patient number 3 in the ICU was caused by bilateral vocal cord paralysis which led to cerebral hypoxia. Because of the patient's deteriorated neurological condition prior to treatment, this death was not attributed to the choice of conservative treatment. Four tracheotomies (3 open and 1 percutaneous) were performed to wean patients from prolonged mechanical ventilation (3 cases) and to treat the injured cartilaginous wall of the anterior cervical trachea (1 case, number 2). No stenoses or other tracheobronchial alterations were found on endoscopic follow up.

Discussion

Traumatic tracheobronchial injuries are uncommon and are associated with other injuries, which is why diagnosis is often delayed.[8] Between 30% to 80% of patients with such injuries die during transport to the hospital, despite improvements in emergency ambulance services.[3] Kiser et al[9] identified 265 patients in 2001 with traumatic tracheobronchial injuries caused by blunt trauma; of these, 59% were caused by motor vehicles.[9] For patients whose condition has been stabilized, postdiagnostic mortality has decreased

TABLE 4
Diagnostic Delay. Type of Surgery, Length of Hospitalization, and Complications*

Case	Diagnostic Delay, hours	Hospitalization, DI/ICU/Total	Approach	Type of Surgery	Complicationss
1	2	1/4/8	Cervicotomy	Resection. Anastomosis	Abstinence syndrome
2	5	1/2/9	Cervicotomy	Tracheotomy	No
3	6	5/6/12	–	–	Death
4	3	0/3/7	–	–	No
5	6	0/5/19	–	–	No
6	6	8/10/18	Cervicotomy	Tracheal repair	No
7	5	30/36/38	Thoracotomy	Bronchial repair	No
8	48	3/4/13	Thoracotomy	Bronchial repair	No
9	7	17/24/27	Thoracotomy	Tracheobronchial angle repair	No
10	5	27/30/31	Thoracotomy	Bronchial repair	No
11	20	14/16/19	–	–	No
12	8	18/20/23	Thoracotomy	Bronchial repair	No
13	24	1/3/7	Thoracotomy	Right pneumonectomy	No
14	6	4/12/17	Thoracotomy	Bronchial repair	No
15	3	12/15/24	Thoracotomy	Bronchial repair	No

*DI indicates days intubated; ICU, days in the intensive care unit; total, total days in hospital.

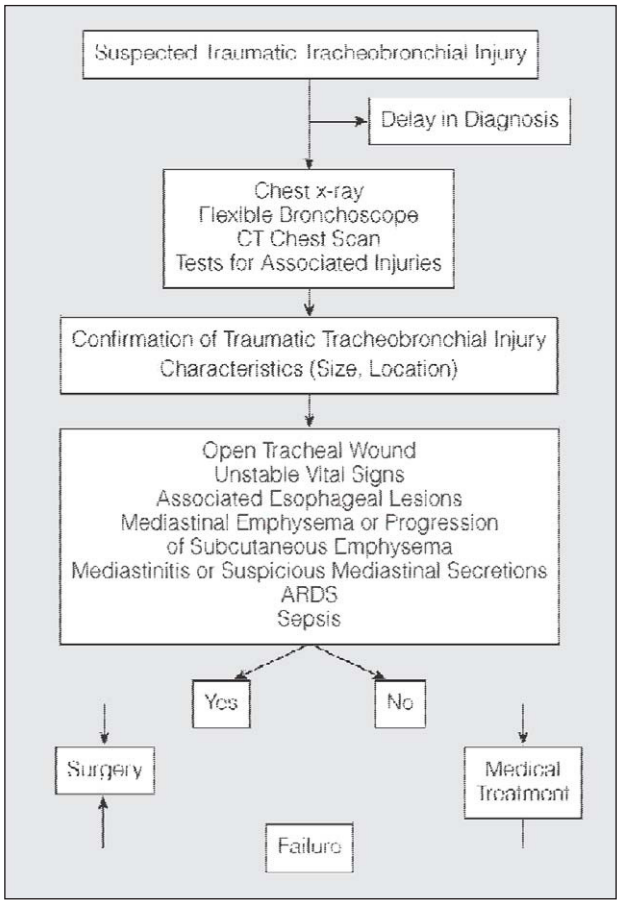

Figure 1. Therapeutic algorithm for traumatic tracheobronchial injuries. CT indicates computed tomography; ARDS, acute respiratory distress syndrome.

considerably over the years, from 50% to approximately 9% currently.[9] It should be noted that tracheobronchial injuries caused by intubation or interventions involving the airways are probably the most common cause of traumatic laryngotracheal injuries, especially for intubations in women and with double-lumen intubation.[10]

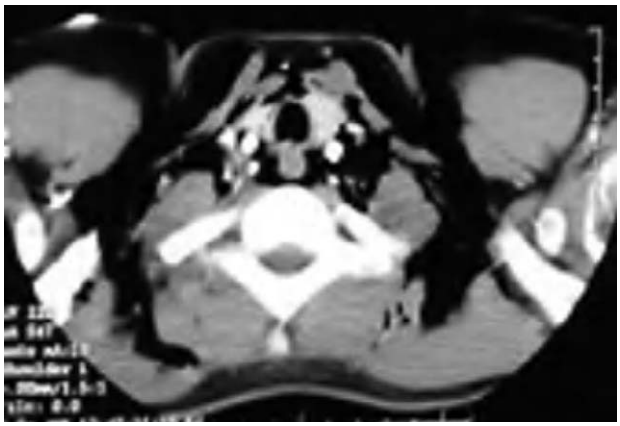

Figure 2. Computed tomography chest scan of case 5. The patient had a traumatic injury with subcutaneous cervical emphysema without subsequent progression and underwent conservative treatment. The injury involved the thoracic trachea and bronchi without associated pneumothorax.

It is well-known that early diagnosis of the injury is essential to determine the appropriate medical or surgical approach and thereby improve the outcome of any eventual surgical intervention.[11,12] This is why the ability to use a fiberoptic bronchoscope—the best diagnostic tool available—is necessary.[2,10]

The most important negative factor affecting surgical outcome is delay in diagnosis.[11] Therefore, emergency intubations should be performed with endoscopic assistance to avoid exacerbating the original injury or creating a false passage.[13]

Conservative treatment has been described as particularly appropriate for postintubation iatrogenic injuries.[14-18] However, in our experience, conservative treatment is also appropriate for noniatrogenic traumatic tracheobronchial injuries (Figure 1).[16] An associated esophageal lesion requires immediate surgical repair given the risk of mediastinitis.[19] Although some groups are strongly opposed to conservative treatment, our results have been very good when strict criteria are followed and the patient is closely monitored in the ICU.[2,12] Our series—the largest one published to date—supports conservative treatment when no contraindications are present.

The size of the injury is not, by itself, an indication for either medical or surgical treatment, despite the views held by others.[14,15,20] It is evident that conservative treatment is more likely to be successful in cases with small lesions to the membranous tracheal wall; however, conservative treatment presents greater risk when lesions are larger than 4 cm.[10,14,15] In our series, a conservative approach was not taken with larger lesions; however, this was not due to any limits placed on the size of the injury, but rather because other criteria for conservative treatment were not met. Bronchial involvement is not, by itself, an indication for surgery (Figure 2). The initial choice of conservative treatment should be studied carefully and multiple images should be obtained to rule out the presence of mediastinal secretions. Surgery may become necessary, however, during the early follow up (Figure 3) of a lesion initially treated conservatively (Figure 4).[20] An early diagnosis is not, in our opinion, a reason for surgery in all cases, contrary to the opinion of other predominantly surgical groups.[2,12] Conservative treatment, on the other hand, may be preferable when diagnosis has been significantly delayed, depending on the condition of the tissues adjacent to the lesion.

The surgical treatment of choice is tracheobronchial repair whenever possible (Figure 3).[2,6,7,20-22] Autologous (pleural, intercostal, and pericardial) tissue should be used to cover the tear.[2] Although lung resection is necessary in certain cases, it should be avoided whenever possible.[7,21,22] Nevertheless, during postoperative endoscopic follow up after repair of the main bronchus, difficult to resolve stenoses requiring a deferred pneumonectomy often develop in the first 18 months.[21]

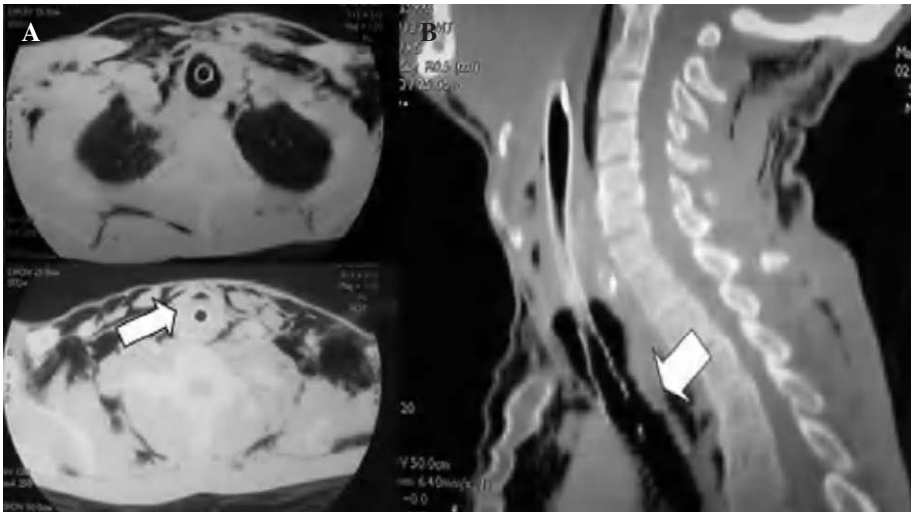

Figure 3. Computed tomography (CT) of the chest and cervical trachea of case 1. The patient's tracheal injury was caused by a knife. A: CT slice, where the arrow indicates the intratracheal air-fluid level. Significant mediastinal and subcutaneous emphysema. Chest tube inserted due to pneumothorax. B: Reconstruction of cervical CT, with an arrow indicating the injury to the cervical trachea.

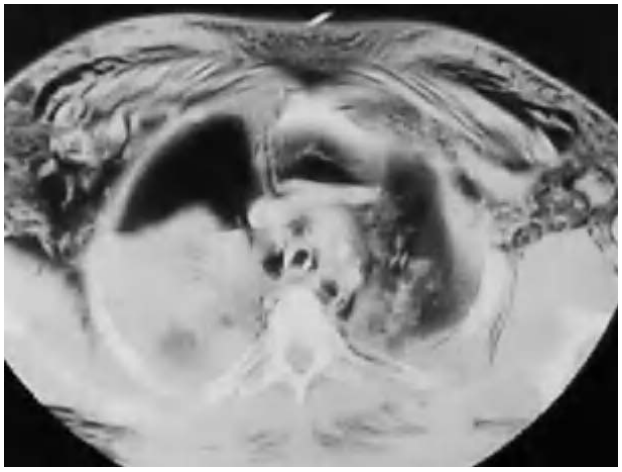

Figure 4. Computed tomography chest scan for case 10. The patient had a traumatic bronchial injury. After being transferred from a referral hospital, the patient underwent surgery without lung resection. Initial treatment in this case was conservative without bronchial repair; however, increased subcutaneous emphysema, traumatic pneumothorax, and nearly complete atelectasis of the right lung made bronchoplasty necessary.

No complications from the tracheobronchial repair occurred in our series, although other authors have reported the infrequent appearance of complications.[6,21]

The most common surgical approach is cervical, although the thoracic approach was used more often in our series.[7] The transcervical approach described by Angelillo-Mackinley[23] is useful in lesions limited to the distal membranous trachea. Thoracotomy is the recommended approach for injuries to the bronchi, the lower thoracic trachea, or the tracheal carina. In our series, most lesions occurred on the right side, which is consistent with reports published in international journals.[22] The use of broad spectrum antibiotics is advisable whether treatment is surgical or conservative.[15,16,19,20]

Associated injuries usually prolong the need for mechanical ventilation, which is why we prefer surgical tracheotomy in cases likely to present weaning difficulties. If the likelihood of prolonged intubation is low, we do not perform any procedures that might cause further tracheal trauma and extubation is carried out as soon as possible.

In conclusion, the treatment of traumatic tracheobronchial injuries should be multidisciplinary, with the involvement of a chest surgeon, an intensivist, and bronchoscopists. The choice of treatment should be guided by strict criteria. Conservative treatment has a high likelihood of success in patients who meet strict selection criteria, even though most cases in our series required initial surgical treatment. A large lesion size, early diagnosis, or certain locations do not contraindicate conservative treatment; however, a large lesion is likely indicative of a worse prognosis. According to case series published to date, conservative treatment in patients with a lesion larger than 4 cm may present risks given the high probability of complications and the minimal possibilities of meeting the criteria for using this approach.

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