

Management of blunt tracheobronchial trauma in the pediatric age group

Q. Ballouhey · R. Fesseau · V. Benouaich · S. Lagarde ·
S. Breinig · B. Léobon · P. Galinier

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Abstract

Introduction Tracheobronchial rupture (TBR) due to blunt chest trauma is a rare but life-threatening injury in the pediatric age group. The aim of this study was to propose a treatment strategy including bronchoscopy, surgery and extracorporeal membrane oxygenation (ECMO) to optimize the emergency management of these patients.

Methods We reviewed a series of 27 patients with post-traumatic TBR treated since 1996 in our pediatric trauma center.

Results Seven cases had persistent and large volume air leaks. Flexible bronchoscopy was performed in cases of

persistent or large volume air leaks. It permitted accurate visualization of the rupture and its extent. It allowed for a clear-cut positioning of the endotracheal tube. Five were managed operatively. Four cases were considered to be life-threatening because of the combination of severe respiratory distress with hemodynamic instability. One of them had severe tracheal laceration and died. Another one had bilateral bronchi disconnection. Based on clinical and endoscopic findings, surgical repair was performed using extracorporeal membrane oxygenation as a ventilatory support. It provided quick relief from the injury, which was previously expected to result in a fatal issue.

Conclusions Prompt diagnosis and accurate management of surviving patients admitted to emergency rooms are necessary. Bronchoscopy remains a critical diagnosis step. Surgery is warranted for large tracheobronchial tears and ECMO could be beneficial as supportive therapy for selected cases.

Q. Ballouhey (✉) · P. Galinier
Department of Pediatric Surgery, Children's Hospital,
330 Avenue de Grande-Bretagne TSA 70034,
31059 Toulouse Cedex 9, France
e-mail: q.ballouhey@gmail.com

R. Fesseau
Department of Pediatric Anesthesiology,
Children's Hospital, 330 Avenue de Grande-Bretagne
TSA 70034, 31059 Toulouse Cedex 9, France

V. Benouaich
Department of Cardiac Surgery, Rangueil Hospital,
1 Av J. Poulhes, 31059 Toulouse Cedex 9, France

S. Lagarde
Department of Radiology, Rangueil Hospital,
1 Av J. Poulhes, 31059 Toulouse Cedex 9, France

S. Breinig
Pediatric Intensive Care Unit, Children's Hospital,
330 Avenue de Grande-Bretagne TSA 70034,
31059 Toulouse Cedex 9, France

B. Léobon
Department of Pediatric Cardiac Surgery, Children's Hospital,
330 Avenue de Grande-Bretagne TSA 70034,
31059 Toulouse Cedex 9, France

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Introduction

Tracheobronchial ruptures (TBR) are rare in the pediatric age group [1]. They are defined as life-threatening ruptures of the trachea or bronchi localized between the level of the cricoid cartilage and the division of the lobar bronchi into their segmental branches [2]. The vast majority of blunt tracheobronchial traumas are due to blunt force, usually from motor vehicle accidents [3].

Anatomical differences between the pediatric and adult thorax could explain the patterns of injury observed in children with a sustained major blunt chest trauma. The elasticity of the thoracic cage protects young children from

Table 1 Main characteristics of patients with tracheobronchial traumas

Management modality	Number of patients	Mean ISS	Mean age (years)	Side (left/right)	Bronchoscopy	Mean chest drainage duration (days)	Mean hospital stay (days)	Death
Chest drainage	22	21.6 ± 7.5	8.6 (1–16)	10/12	2 (7 %)	6 (4–10)	14 (10–43)	0
Surgery	5	38.6 ± 9.4	6.8 (2–13)	1/5	5 (18 %)	11 (7–19)	21 (13–64)	1 (3 %)

sustaining injuries of the chest wall. Intra-thoracic structures may be compressed without any evidence of overlying injury. In the case of crush syndrome or high-level kinetic trauma, a rapid increase in tracheobronchial pressure may explain blowout perforation of the trachea without rib fracture. Most tracheal injuries occur within 2.5 cm of the carina, and the right mainstem bronchus is more frequently affected than the left one [4].

Most of the patients with major tracheobronchial trauma die from associated injuries before reaching the hospital [5]. The initial clinical presentation may be variable and non-specific [2] and the management can be extremely challenging. Prompt diagnosis and efficient treatment are major prognostic factors of these rare injuries with high mortality rates [5]. The aim of this study was to propose a treatment strategy to optimize the emergency management of these patients.

Methods

Between January 1996 and December 2011, 27 patients (11 females; 16 males) with a mean age of 8.2 ± 4.1 (1–16) years were referred to our level 1 trauma center for blunt tracheobronchial traumas. Accurate diagnosis was difficult because of the paucity of clinical symptoms compared to the adult population. Conservative management consisted of chest drainage using one or two thoracostomy tubes for large pneumothoraces. The CT was performed after obtaining hemodynamic stability. In cases of persistent (more than 24 h) or large volume air leaks, a bronchoscopy was performed. Surgery was elected as management for severe lesions defined as tracheal lacerations, large circular tears or main bronchus avulsions. In the case of severe respiratory failure, extracorporeal membrane oxygenation (ECMO) was accessible at any time as a support if resuscitation failed to restore a stable condition. It was only available in the last five years of this study. Data were reviewed retrospectively and the study was approved by our hospital's ethics committee.

Results

The causes were a road accident in 16 cases (59 %) and fall in 11 cases (41 %). Associated injuries were detected in 18 patients (66 %) and the mean injury severity score (ISS)

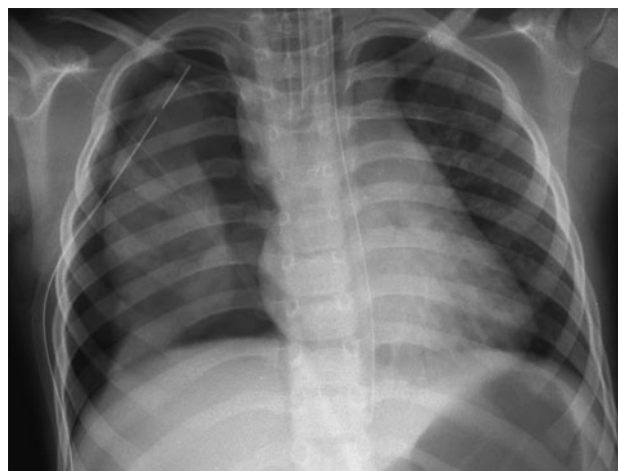


Fig. 1 Chest X-ray. Pneumothorax with complete right lung collapse and persistent air leak in the chest tube

was of 24.8 ± 10.2 . One of them died. The other children recovered uneventfully and regular bronchoscopy did not reveal any tracheobronchial stenosis.

Twenty-two patients (81 %) were managed conservatively (Table 1). Mean duration of chest drainage was 6 days (4–10) and mean hospital stay was 14 days (10–43).

Seven patients had persistent air leaks in spite of appropriate drainage. After bronchoscopy, two were managed non-operatively with a mean duration drainage of eight days (6–10). The CT was useful to detect associated injuries like intracranial haemorrhage but didn't accurately delineate the extent of the tracheobronchial tear. Five were managed operatively (mean ISS 38.6 ± 9.4). Mean duration of chest drainage was 11 days (7–19) and mean hospital stay was 21 days (13–64). Four cases of TBR were considered to be life-threatening because of the combination of severe respiratory distress with hemodynamic instability.

Three children were transferred to our hospital after being involved in road traffic accidents. Complete disruption of the trachea for the first one and complete right main bronchus avulsion for the others were confirmed. Primary repair was performed and ECMO was applied for one patient with bilateral pulmonary contusion as postoperative ventilatory support. A 10-year-old girl sustained a crush injury to her torso when her horse fell on her and pinned her to the ground. Despite a right chest tube, chest X-ray revealed a complete right lung collapse (Fig. 1). Fiber optic

endoscopy revealed an 8-cm-long laceration of the last part of the membranous trachea, extending to the right transected mainstem bronchus. The laceration was so severe that we had to perform a right pneumonectomy. She died of multiple organ failure on the 3rd postoperative day. At that time, ECMO was not available in our institution. One challenging case was a 32-month-old girl crushed by a van involving bilateral bronchi disconnection (Fig. 2). She received preoperative ECMO for respiratory support and the outcome was survival of the patient.

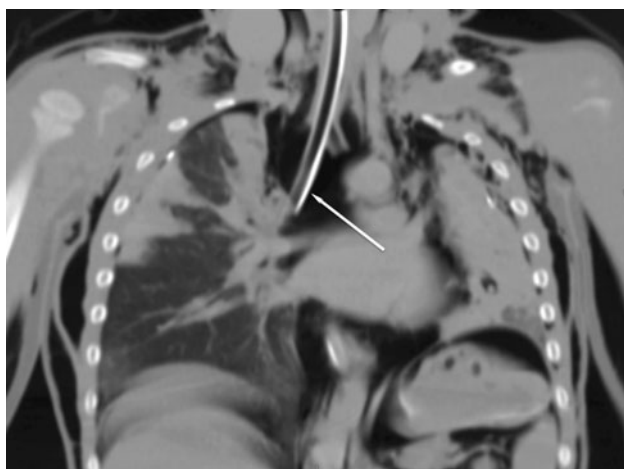


Fig. 2 CT scan. This coronal reconstruction shows bilateral bronchi disconnection with major emphysema and bilateral pneumothoraces. The tracheal tube (arrow) is seen within a massive pneumomediastinum

Discussion

Major tracheobronchial traumas are life-threatening injuries causing severe respiratory distress and hemodynamic instability. Severe injuries caused by a blunt mechanism can present diagnostic difficulties if no external sign is present. Because tracheobronchial are rare injuries requiring prompt management, we thought it necessary to propose an algorithm to optimize their emergency management (Fig. 3).

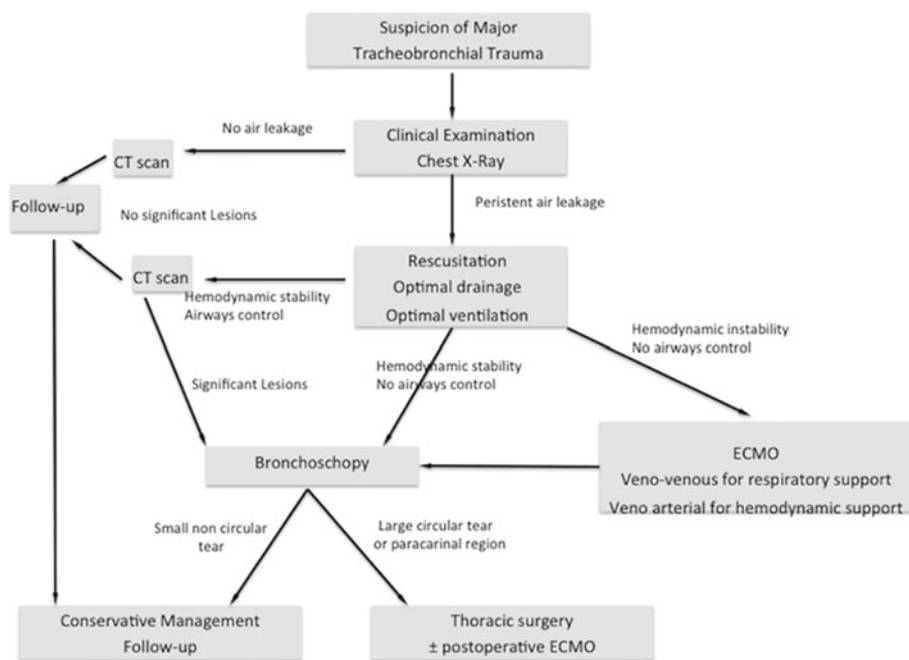
Initial assessment

Children with a suspected thoracic injury first require airway assessment. After resuscitation and chest drainage, certain clinical manifestations such as extending subcutaneous emphysema, respiratory distress, hemoptysis or hemodynamic instability should alert the physician. In such cases, efficient tracheal intubation is required but can be difficult because of anatomical changes [6].

Persistent, large volume air leaks despite adequate chest drainage are highly suggestive of a large tracheobronchial tear. In case of mechanical ventilation, the pneumothorax is then difficult to contain with chest tubes.

The chest X-ray remains the most informative diagnostic tool. Indeed, a disruption of the tracheal air column, massive atelectasis, deep cervical emphysema and pneumomediastinum, in association with the pneumothorax, are highly suggestive of a severe tracheobronchial rupture. The fallen lung sign is pathognomonic of a total rupture of the main bronchi [7]. The place of CT in the management of pediatric blunt tracheobronchial trauma is still controversial [8].

Fig. 3 Algorithm. Management of major tracheobronchial trauma in the pediatric age group



Selected cases include patients with hemodynamic stability but abnormal chest X-rays [9]. Its greatest value is in detecting small lesions, such as mediastinal emphysema, which are not visible in chest X-rays [2]. Such cases correspond to patients only managed with thoracic drainage [10] and are not the subject of this study. As advocated by some authors, CT can significantly delay emergency care [11, 12]. In cases with hemodynamic stability and suspected life-threatening injuries, especially neurological ones, CT is required.

Airway control

The critical step of TBR diagnosis is bronchoscopy. It should be performed by experienced thoracic surgeons or pulmonologists in a fully equipped operating room. It remains the gold standard for establishing the diagnosis.

It can also be a critical tool to maintain adequate ventilation. We recommend flexible bronchoscopy with guidance because it allows for the adjustment of the endotracheal tube in the disrupted airway or selectively intubating the non-injured mainstem bronchus [13]. If the tracheal rupture is proximal, bridging of the lesion may be possible and should be preferred [14]. If the tracheal rupture involves the lower third of the trachea, carina or both mainstem bronchi, the selective intubation of the bilateral mainstem bronchus through a large tracheotomy has been proposed [6]. The initial endotracheal tube must be uncuffed to avoid increasing the damage and to be readily repositioned for inspection of the rims of the rupture. The bronchoscope can be used as a stent, over which the repair can be made. Sometimes, we can miss the diagnosis with bronchoscopy [5]. In unclear situations, a blast injury could be suspected, as in our cases.

Further management depends on the anatomy of the injury. Conservative management is possible for small ruptures by re-intubation with a tracheal tube cuff inflated distal to the tear [14]. The bronchoscopic criteria for surgery include tears involving the full thickness of the tracheal wall, tears longer than 2 cm, and transmural ruptures involving the paracarinal region [2].

Surgical management

In case of clinical instability because of a massive hemorrhage or persistent air leak, despite the placement of several chest tubes, surgical intervention is warranted even if the diagnosis has not been previously confirmed by bronchoscopy [5]. In such cases, surgical intervention is necessary as a life-saving procedure, although mechanical ventilation can be very difficult.

The choice of surgical approach depends on the location and the length of the tear. Injuries of the cervical trachea

are best managed by cervical incision. A right posterolateral thoracotomy in the fourth intercostal space provides good exposure to the distal trachea and mainstem bronchi. A left thoracotomy is only preferred for isolated transverse ruptures of the left mainstem bronchus [9]. The surgical procedure should be as conservative as possible, favoring primary anastomosis, and considering lobectomy or pneumonectomy as a last resort. Transverse ruptures are repaired with interrupted absorbable sutures, whereas longitudinal ruptures might be repaired with continuous sutures [5]. The treatment of total bronchial or tracheal rupture consists of surgical exploration and primary repair [2].

ECMO

The ECMO can be proposed as a therapeutic modality to provide cardiorespiratory support after a blunt chest trauma. Severe trauma injuries are considered to be a contraindication for ECMO because of the risk of unstoppable bleeding or intracranial hemorrhage. However, ECMO was proposed as a support in pediatric patients with post-traumatic respiratory failure or acute respiratory distress syndrome [15]. The ECMO is also considered to be a supportive therapy for the postoperative period in patients with severe pulmonary contusion or to prevent barotrauma after bronchial repair. Recent reports of adult patients with venovenous ECMO have been published for the management of endobronchial hemorrhage [16] or surgical bronchial repair after iatrogenic [17] or traumatic rupture [18]. If airway control is impossible, ECMO can be indicated. The timing of ECMO after a severe trauma is considered to be critical. For pediatric patients with major TBR, we believe that instituting ECMO as soon as possible after optimal drainage and ventilation presents beneficial effects. Cannulation can be initiated before surgery or in case of instability or prediction of major ventilation difficulties during thoracic surgery. In case of doubt, the access for cannulation should be accessible during surgery. Guide wires can also be inserted before surgery to save time. The ECMO can be instituted after surgical repair in case of persistent ventilation difficulties or to prevent barotrauma from occurring.

In the case of tracheal blast injury or complete avulsion of both bronchi, a cardiopulmonary bypass can be considered as an alternative method of ventilatory support [19]. In our experience, ECMO allowed for surgical repair in good conditions because mechanical ventilation could be interrupted [17]. We believe that venoarterial cannulation should not only be reserved for patients with intrinsic myocardial dysfunction, but could also be beneficial to patients with hemodynamic instability. Venovenous ECMO is preferred because the blood flow is easily

maintained. It offers theoretical benefits by allowing native pulmonary flow, thus increasing pulmonary alveolar oxygen content [20]. An ECMO in children is mainly achieved by cannulation of the femoral and jugular veins. The ECMO initiation and weaning should begin as early as possible. If decannulation is planned, we recommend attempting a repair of the vessels, particularly the ligated carotid artery. We did not experience complications, such as circuit thrombosis or hemorrhage.

The application of ECMO for major blunt tracheobronchial trauma was published recently and for the first time with this challenging case of bilateral bronchi disconnection [21]. In this case, ECMO was a treatment of “last resort.” Determining early the most appropriate candidates is very critical. The benefits of this invasive procedure are to be weighed against its potential complications. In our experience, there are few cases of severe blunt chest traumas for which ECMO could be initiated. Before it was available in our center for the management of these life-threatening injuries, we experienced major difficulties with the management of some patients, sometimes resulting in their death. We consider it as a significant advantage and would recommend it as a fundamental emergency measure for major TBR in a trauma center.

Conclusion

Severe tracheobronchial traumas in children are some of the most challenging injuries to diagnose and manage. Successful outcome requires their accurate detection with clinical criteria, chest radiography findings and prompt confirmation with bronchoscopy, which confers a definitive diagnosis and provides optimal ventilation. Surgical treatment is mandatory for large and persistent air leaks. The ECMO may play a role as an additional treatment for severe but reversible acute respiratory failures. When initiated before surgery, it allows for surgical repair in better conditions thanks to the possible interruption of mechanical ventilation. Moreover, in selected cases, it provides postoperative respiratory support by maintaining systemic oxygenation without ventilator-induced barotrauma of the lungs and airways.

Conflict of interest None declared.

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