

# Conservative Therapy in Iatrogenic Tracheal Rupture: A Retrospective Analysis and a Call for Research

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## Abstract

**Introduction:** Iatrogenic tracheal rupture is a rare potentially life-threatening lesion. The best treatment has still not been determined in the case of mechanically ventilated patients for whom surgery has a high mortality rate.

The aim of this study is to assess the role of conservative management in patients with iatrogenic posterior tracheal wall perforation and to verify its role in critically ill mechanically ventilated patients.

**Methods:** We reviewed the cases occurred at our hospital: a retrospective study was performed and 7 patients over a four-year period were identified. Conservative treatment consisted in endoscopic evaluation of tracheal tear healing and O<sub>2</sub> therapy when dealing with spontaneous breathing patients with none or few symptoms without progression. When symptoms progressed and spontaneous ventilation wasn't possible, patients underwent tracheal intubation or tracheostomy tube replacement and inflation of the cuff distal to the tear. This conduct has been chosen in membranous trachea injuries, independent of the injury size, diagnostic delay, or cause.

**Results:** Conservative therapy was attempted in 5 over 7 cases, it was successful in all 5 cases without complications. No clinically evident mediastinitis or postoperative tracheobronchial stenosis was observed on endoscopic follow up.

**Conclusion:** Our retrospective analysis showed that nonsurgical treatment could be a safe and suitable solution to achieve tracheal healing secondary to membranous injury. In cases where mechanical ventilation is needed, bridging the tear with the tracheal tube seems to give good results. Surgical treatment is advisable in cases of mediastinitis, progression of emphysema and difficulty in bridging the defect with an artificial airway. In the lack of randomized clinical trials comparing surgical and conservative treatments we reviewed our cases and created the ConservAtive vs surgery registry of tracheal ruPTUREs (CAPTURE registry) to collect data from different centers to provide clinicians with further evidences.

**Keywords:** Bronchoscopy; Intubation; Tracheal laceration; Iatrogenic disease; Conservative treatment; Surgery; Outcome

## Introduction

Iatrogenic Tracheobronchial Rupture (ITBR) is distinct from non-iatrogenic cause of tracheobronchial trauma and often implies a difficult and multidisciplinary management. Iatrogenic tracheal lacerations are rare and account 0.005% for single lumen orotracheal intubations [1] and from 0.05% to 0.19% for double-lumen intubations [2]. It's very difficult to estimate the true incidence because of the very large number of intubations performed daily worldwide and the increasing adoption of pre-hospital emergency intubations.

Other causes of iatrogenic tracheobronchial rupture are tracheotomy, bronchoscopy, placement of stents, esophagectomy, mediastinoscopy and others.

A prompt management of tracheal injuries is always necessary because of the possibility of a life-threatening evolution. However, there is no general agreement about the factors that should address the proper management and treatment indications arise from retrospective analyses based on small and heterogeneous groups of patients [3]. Therefore, there are no criteria for surgical or conservative management. Surgery has been considered the therapeutic gold standard for long time [4] but nowadays a deep change has occurred for therapeutic approach to this kind of lesions with the evidence of the effectiveness of conservative treatment [5].

Non-operative treatment of ITBR is recognized to be effective in case of none or few symptoms in spontaneous breathing patients. In

case of severe tracheal injuries with progression of symptoms such as subcutaneous emphysema or pneumothorax and in critically ill mechanically ventilated patients there are no shared indications.

The purpose of this study is to provide further evidence about the role of conservative strategies.

## Materials and Methods

We reviewed our records to assess incidence of ITBR over a four years (January 2010 to March 2015) period and found 7 patients treated in the S. Anna University Hospital, Ferrara, Italy.

## Population

Clinical records of 7 patients, consecutively treated in our

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department, were analysed to assess patient profile, cause, extent of tracheobronchial injury, clinical symptoms, chosen treatment and patient outcomes.

Tracheobronchial injuries complicating blunt chest trauma, rigid bronchoscopy, or thoracic surgery, asymptomatic tracheal injuries detected during bronchoscopy performed for other reasons and iatrogenic tracheoesophageal fistulas were excluded from the analysis to avoid major confounding factors.

Only patients with TBR assessed by endoscopic evaluation of the upper respiratory tract and chest CT were considered. Bronchoscopy verified the length and location of the TBR with a special attention in determining the lower limit of the lesion and its distance from carina, chest CT was used to detect signs of ITBR such as pneumomediastinum, pneumothorax, pneumoperitoneum, as well as associated complications such as mediastinitis

A multidisciplinary team including thoracic surgeons, anesthesiologists, pulmonologists and intensivists discussed each case. Since this is a retrospective analysis of clinical records informed consent was not required by our local ethical committee; the study was nevertheless performed after our local ethical committee approved the analysis of patients records.

### Treatment options

Conservative treatment was chosen in those patients in whom mechanical ventilation was possible without any loss of tidal volume, and the emphysema was only mild and did not progress during ventilation. In case of severe symptoms or symptoms progression the lesion was bridged by the tube cuff in order to keep the lesion under zero pressure. Spontaneously breathing patients with few symptoms and no symptoms progression underwent medical treatment only.

The ventilation regimen was directed towards early extubation, but in all cases was dependent on associated diseases rather than the tracheal injury itself. Protective ventilation was adopted with low tidal volumes (4-6 ml/Kg ideal body weight), low positive end-expiratory pressure (PEEP) and high respiratory frequency in order to minimize tracheal tear stress. There was also careful monitoring in the intensive care unit for signs of air leaks (loss of tidal volume).

We decided for surgical treatment in case of impossibility to bridge the lesion or subcutaneous or mediastinal emphysema progression.

Surgical repairs were all performed through a right-side thoracotomy at the level of the fourth intercostal space. All patients received empiric broad-spectrum antibiotic therapy and endoscopic examinations were performed at least three times after both surgical and conservative treatments.

## Results

### Patients

There were 5 women (71%) and 2 men (29%), with a mean age of 66 years (range, 37 to 86 years).

Three patients presented with class I obesity, defined as a mean body mass index (BMI) between 30 and 34.9; all these patients were female. Three of the four female patients were short sized. All the others were in the normal range, defined as a mean BMI of 22.9 to 24.9.

Patients' characteristics including Mallampati score are reported in the Table 1.

### Etiology

The injury occurred in one case during single-lumen tube intubation in emergency setting, and in elective situation in two patients. In two patients (29%), the trachea was perforated by double-lumen tube intubation under elective conditions. Two cases (29%) were diagnosed after surgical tracheostomy, one of whom (14%) was associated with an emergency condition.

### Clinical and radiographic findings

All patients showed at least one of the classic symptoms, such as mediastinal emphysema (43%) or subcutaneous emphysema (86%) (Figure 1). Unilateral pneumothorax was seen in two patients (28%) and a bilateral pneumothorax was present in 1 patient (14%). One patient presented also with pneumoperitoneum (14%).

### Circumstances of diagnosis

An ITBR was suspected in all cases by clinicians and confirmed in all cases within 24 hours from the injury in all cases (100%). In one patient (14%), the diagnosis was made after double lumen intubation for a thoracic surgery procedure. Subcutaneous emphysema appeared and prompted a fiber optic bronchoscopy, which evidenced a tracheal tear. Tracheal tears complicating tracheostomy were identified within 24 hours, due to rapidly spreading mediastinal and subcutaneous emphysema.

### Location of tracheal tear

All lesions were longitudinal and located at the posterior membranous part of the trachea. The mean length of the injury was 2.7 cm (range 2.0 cm to 4.0 cm).

In five patients (71%), the lacerations were located in the upper two thirds of the trachea and were covered by the esophagus (Table 2).

Surgical treatment was adopted in two cases (29%): in one case tracheal injury at carina level was detected after double lumen intubation for a thoracic surgery procedure. The second patient underwent surgery seven days after tracheal tear for air leak continuation and emphysema progression.

Bronchoscopy was performed in both conservatively and surgically treated patients and demonstrated local healing. No mediastinitis or late onset stenosis were observed, and no secondary surgical repair was necessary. No mortality was observed in our cohort.

### Discussion

ITBR management deeply differs from traumatic tracheobronchial injuries. This hypothesis is based upon observations that iatrogenic lesions usually present themselves as longitudinal tears of the posterior tracheal wall, and that tissue healing is usually simpler and with a better prognosis when compared with other etiology lesions.

Our retrospective analysis suggests that females, short stature (less than 165 cm), difficult airway anatomy, steroid use, emergency intubations and underlying connective tissue disease could be a risk factor for ITBR. Due to small numbers statistical analysis to identify predictors has not been performed. Mechanical factors such as use of rigid stylets, incorrectly sized tracheal tubes and cuff over-inflation could have also played a role [6]. Massard indicated cuff hyperinflation as a possible mechanism of tracheal injury caused by accidental selective right main bronchus intubation in association with short size of patients [2]. Early diagnosis is of paramount importance and if a rupture is suspected, the diagnostic assessment must include bronchoscopy

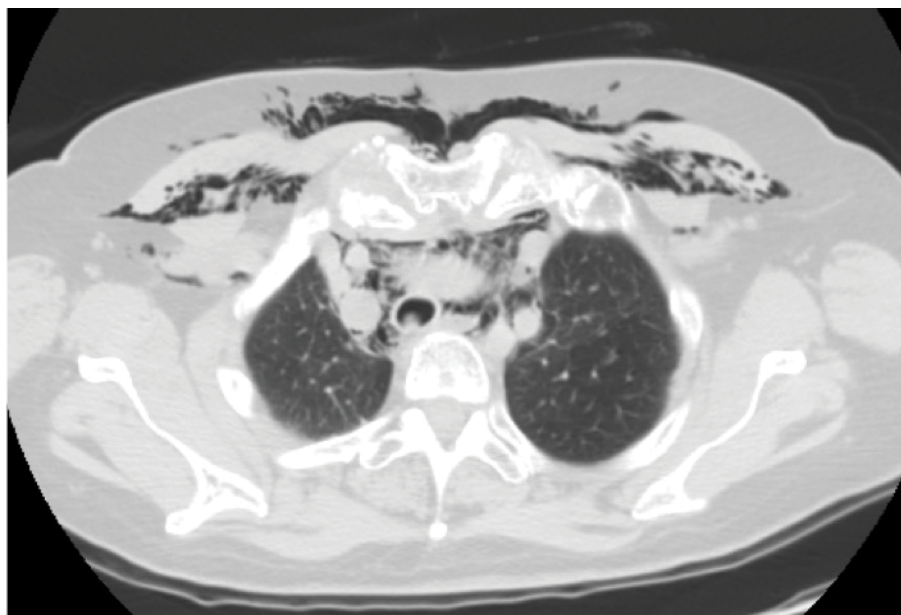


Figure 1: CT scan showing both mediastinal emphysema and subcutaneous emphysema.

Patient	Sex	Age (Y)	BMI	Size (CM)	Mallampati Score	Reason for Intubation	Symptoms
1	F	78	31	161	2	Operation: Hip Replacement	Subcutaneous Emphysema
2	F	79	32	164	2	Operation: Shoulder Surgery	Mediastinal and Subcutaneous Emphysema
3	F	37	21	169	2	Tracheostomy for Anaphylactic Shock	Mediastinal and Subcutaneous Emphysema, Pneumothorax, Pneumoperitoneum
4	F	68	27	156	3	Trauma	Subcutaneous Emphysema
5	M	64	29	180	3	Operation: Thoracoscopic Pleurectomy	Subcutaneous Emphysema
6	M	86	26	173	1	Tracheostomy for Larynx Carcinoma	Mediastinal and Subcutaneous Emphysema, Pneumothorax
7	F	50	34	175	3	Operation: Left Upper Pulmonary Lobectomy	Pneumothorax

Table 1: Patient characteristics.

Patient	Size of the Injury	Location	Distance From Carina (CM)	Treatment
1	2 CM	Upper Third	5	Conservative
2	4 CM	Upper Third	4	Conservative
3	2 CM	Upper /Middle Third	4	Conservative
4	4 CM	Lower Third /Carina	3	Surhery
5	2 CM	Carina /Right Main Bronchus	0.5	Surgery
6	2 CM	Upper /Middle Third	5	Conservative
7	3 CM	Upper Third	1	Conservative

Table 2: Tracheal injury characteristics.

to assess the lesion's length, thickness and location, and eventual protrusion of mediastinal structures [7]. Chest X-rays might show tissues dissection due to air, while a CT scan can be helpful in detecting pneumothorax, pneumomediastinum, pleural and mediastinal fluid collection and anatomic details of the lesion. Finally, esophagoscopy can rule out a coexisting esophageal lesion. In one case, abdominal distension and subsequent tension pneumoperitoneum occurred after relief of acute airway obstruction owing to a tracheal membranous flap being released. The high positive airway pressure through the ITBR likely maintained an air pressure gradient between the mediastinum and peritoneum across the central diaphragmatic crura.

The most controversial part of ITBR management remains the therapeutic approach.

Surgical repair has traditionally been considered as the mainstay of treatment: this recommendation is based on the hypothesis that tracheal perforation increases the incidence of mediastinitis and late tracheal stenosis. However, there are no randomized trials to support this recommendation. In addition surgical repair of tracheal injuries, especially in ICU-mechanically ventilated patients, is a high-risk procedure with a reported mortality rate of 42% [8]; this rate alone provides a rationale for considering alternative approaches in managing tracheal injuries.

Selection criteria for non-operative management are still debated: some studies discussed the role of TBR length as an indication for surgical management. In the retrospective study by Hofmann [8], 19 tracheal iatrogenic lesions ranging from 1 to 7 cm were treated surgically and a single patient underwent fibrin glue repair of a 1 cm lesion; the authors indicated 2 cm as the limit below which a conservative approach should be adopted, and above which surgery was considered the best option. According to them, Carbognani and colleagues chose nonsurgical therapy in small, uncomplicated tears (<2 cm) in stable patients [9].

Some authors reported good results avoiding surgery in selected cases [10]: patients with stable vital signs, absence of sepsis related signs, spontaneous breathing, short lacerations without trachea-esophageal fistula, minimal or non-progressive pneumo-mediastinum or subcutaneous emphysema, didn't undergo surgery

The decision for surgery or not is difficult in critically ill mechanically ventilated patients, with TBR: conservative management is considered to fail, but on the other hand, these patients have the highest perioperative risk for surgical treatment.

Gomez-Caro [11] showed that the outcome of conservative strategy was completely independent from the classic criteria of lesion length, thus widening inclusion parameters for conservative treatment and stressing the role of respiratory autonomy as the most important factor that should address the correct treatment choice. In Conti's study, [12] non-operative treatment was adopted only in patients breathing spontaneously or who could be weaned immediately regardless of the size and location or in patients requiring mechanical ventilation with unacceptable surgical risk.

Our study, according to Gomez-Caro and Conti observations [11,12], found that outcome was independent of the TBR length. Lesions below or close to the tracheal carina may be treated via emergency thoracotomy with surgical repair. Persistent air leak despite positioning of the artificial airway just above the tracheal carina also limits a conservative approach, indicating a defect too close to the bifurcation for bridging. However, if the tracheal tear is localized in the trachea's upper or middle third, conservative treatment can be performed with no additional surgical risk.

Our cases show that conservative treatment of ITBR appeared to be safe and was not associated with mediastinitis or tracheal lumen obstruction.

The only limiting factor was represented by the impossibility to bridge the lesion with the cuff of an endotracheal tube inflated below the tracheal lesion. As a result, the surgical option is recommended only in those cases in which the lesion could not be bypassed with the tube cuff or in which massive air leak is observed.

An alternative conservative approach is the use of covered expandable metallic tracheal stents: only few studies have been published reporting good results with early extubation [13].

However, this treatment associated with granulation tissue formation, halitosis, stent fracture and migration, and recurrent respiratory infections requiring close bronchoscopic tracheal surveillance [14]. We therefore believe that bridging the defect provides less complications rate and should be the treatment of choice.

The most interesting result in our study was that none of our patients acquired a mediastinitis and that all tracheal defects healed without stenosis. These results are encouraging because a nonsurgical approach has previously been suggested to evoke mediastinitis and tracheal stenosis [15]. Nevertheless, antibiotic therapy should always be considered in cases of tracheal perforation.

Our criteria for choosing non-operative management were uncomplicated mechanical ventilation without any loss of tidal volume and no subcutaneous or mediastinal emphysema progression during ventilation.

## Conclusions

Treatment strategies of iatrogenic lesions are still controversial and are influenced by lesion localization rather than its length or depth. Surgical management is strictly dependent on pre-existing comorbidities and tracheal tear location. Conservative treatment by bridging the defect with an artificial airway is a feasible treatment and an alternative to surgery in high-risk patients. All lesions in our case study healed without stenosis, signs of local inflammation, or mediastinitis.

## Implication for future research

To provide further evidence of the role of conservative management vs surgical management of TBR we created a registry to collect data from different centers. Supplemental material (Supplementary file 1) consists of a form, to be completed and sent to our corresponding address. In this way we aim to collect data from different settings. We estimated that at least 110 cases are required to perform a statistical analysis with appropriate power. In a first instance we plan to collect retrospective data, thus to assess variables associated with ITBR and with patient centered outcomes (survival, complete healing, time to discharge, hospital length of stay). All clinicians who will collaborate to our data collection will be included in the final publication. A special thank goes to the editor who granted us the opportunity to make this call for research.

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