Management of Postintubation Tracheobronchial Ruptures*

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Study objectives: **To determine whether nonoperative management can be applied to iatrogenic postintubation tracheobronchial rupture (TBR).**
Design: **Prospective cohort study.**
Patients and interventions: **Thirty consecutive patients with TBR complicating intubation between June 1993 and December 2005 entered the study. Patients not receiving mechanical ventilation at time of diagnosis were treated nonsurgically. Patients receiving mechanical ventilation who were judged operable underwent surgical repair, while nonoperable candidates had their TBR bridged by endotracheal tubes.**
Results: **Fifteen patients not requiring mechanical ventilation underwent simple conservative management. TBR length measured 3.85 ± 1.46 cm (mean ± SD). Eight TBRs showed full-thickness rupture with frank anterior intraluminal protrusion of the esophagus. In three patients, transient noninvasive positive pressure ventilatory support (NIV) was necessary. All lesions healed without sequelae. Two patients receiving mechanical ventilation underwent surgical repair and died. Thirteen patients receiving mechanical ventilation were considered at high surgical risk, and TBR bridging was attempted as salvage therapy. Complete bridging was achieved in five patients by simply advancing the endotracheal tube distal to the injury. Separate bilateral mainstem endobronchial intubation was necessary in six patients whose TBRs were too close to the carina. Nine of 13 patients (69%) treated with nonoperative therapy completely recovered.**
Conclusion: **We conclude that conservative nonoperative therapy should be considered in patients with postintubation TBR who are breathing spontaneously, or when extubation is scheduled within 24 h from the time of diagnosis, or when continued ventilation is required to treat an underlying respiratory status. Surgical repair should be reserved for cases in which NIV or bridging the lesion is technically not feasible.** ***(CHEST 2006; 130:412–418)***

Key words: injury; intubation; mechanical ventilation; rupture; surgery; trachea

Abbreviations: NIV = noninvasive positive pressure ventilatory support; TBR = tracheobronchial rupture

Tracheobronchial rupture (TBR) is an uncommon but potentially serious complication of endotracheal intubation. Iatrogenic TBR should be differentiated from tracheobronchial injuries of traumatic origin since it has different mechanisms leading to different morphologic appearance and therapeutic options.[1] Traumatic TBR is usually the result of blunt chest trauma and appears as horizontal or irregularly shaped disruptions involving the main carina and often extending into the main bronchi. Iatrogenic TBR, in contrast, usually presents as longitudinal lacerations of the pos-

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The authors report that they have no conflicts of interest related to this paper.
Manuscript received November 19, 2005; revision accepted January 30, 2006.

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DOI: 10.1378/chest.130.2.412

terior tracheal wall either centrally located, or laterally such that the membranous wall is avulsed from its cartilaginous insertion. Extension into either mainstem bronchi is rare. Predominance in women has been documented.[1–3] Iatrogenic TBR may occur in the absence of difficult intubation, use of a stylet, or cuff overinflation. The exact mechanism remains uncertain, but the most probable explanation is a direct laceration from an endotracheal tube tip caught in a fold of a flaccid posterior tracheal membrane, while advancing the tube.

Management of iatrogenic TBR is controversial. Early surgical repair has traditionally been considered as the cornerstone of therapy.[2–9] There is, however, a growing body of evidence showing that iatrogenic TBR can be dealt with conservatively in selected cases.[10–21] Selection criteria for nonoperative management are still debated. While most authors[1,12,14,16,19] agree on the fact that there should be no evidence of respiratory or hemodynamic instability, esophageal injury, mediastinitis, or progressive pneumomediastinum, others[2,4–9,18,21] also consider the size and the depth of the defect as important criteria, advocating surgery whenever full-thickness or lengthy lacerations are present. Critically ill patients, especially those in whom TBR results from emergency intubation, may fulfill all the criteria for surgical repair. Surgery in these patients involves a high risk, with a reported mortality as high as 71.4%.[7] Such a high mortality for the repair of TBR in critically ill patients receiving mechanical ventilation demands that alternatives to high-risk surgery be considered.

Based on the data available in the literature and on our previous experience,[17] we designed a multidisciplinary management protocol integrating both operative and nonoperative strategies. We report herein the results of this approach in a consecutive series of patients with iatrogenic TBR.

Materials and Methods

Setting

This study took place in the emergency and critical care department and the department of thoracic surgery and respiratory diseases of a university-affiliated hospital that serves as a referral trauma center for a region of 4 million inhabitants.

Study Population and Inclusion Criteria

All patients with TBR complicating endotracheal intubation between June 1993 and July 2005 entered the study. Excluded were tracheobronchial injuries complicating blunt chest trauma, tracheostomy, rigid bronchoscopy, or thoracic surgery.

Procedures and Protocol

All patients underwent fiberoptic bronchoscopy and chest CT. The length and location of the TBR was determined by bronchoscopy with a special attention paid to the lower limit of the rupture. Chest CT was used to detect direct or indirect signs of TBR (pneumomediastinum, pneumothorax, pneumoperitoneum) as well as associated lesions (mediastinitis). Each case was discussed by a multidisciplinary staff including thoracic surgeons, anesthetists, pulmonologists, and intensivists. Our approach to treatment was based on two key factors: first, the need for mechanical ventilation; and second, the ability of the patient to tolerate a surgical intervention related to their underlying medical condition.

Two clinical scenarios were identified. In the first scenario, the diagnosis was made in a patient breathing spontaneously, or who could be weaned immediately, with no need for further mechanical ventilation expected in the upcoming days. In these patients, nonoperative management was considered regardless of the size and location of the TBR or the time interval from extubation to diagnosis. Patients were carefully followed up clinically and via bronchoscopy (every other day during the first 10 days and weekly until cure thereafter). Oral intake of food was withheld for the first 2 to 5 days until esophageal injury was eliminated and the patient's status had stabilized. Antibiotics were prophylactically administered for the first 3 days to prevent mediastinitis. Oxygen was administered when necessary. Noninvasive positive pressure ventilatory support (NIV) was provided in case of mild respiratory distress.

In the second scenario, the patient still required mechanical ventilation at time of diagnosis because of respiratory failure or for other reasons (*ie*, coma, multiorgan failure). In these patients, the decision to surgically repair the TBR depended on the severity of the underlying illness. If the multidisciplinary staff deemed the patient to be operable, surgical repair of the TBR was immediately undertaken in order to restore effective ventilation. In patients with an unacceptably high operative risk, conservative management was followed. In these cases, surgery was reserved as a salvage option in case of TBR-related uncontrolled air leaks or mediastinitis.

In operable patients, the first step was to determine an appropriate intraoperative anesthetic management in order to maintain oxygenation and ventilation without compromising surgical repair. Intraoperative selective lung intubation with tubes placed bronchoscopically was used in order to bypass the lesion. Extension of TBR determined the surgical approach (posterolateral thoracotomy for lesions extending to the distal third of the trachea, and cervical approach otherwise).

When surgery was considered to be high risk, the aim was to prevent widening of the injury during inspiration. To do so, the lesion was bridged in order to keep the lesion under zero pressure (under mechanical ventilation, positive pressure is distal to the endotracheal cuff). The bridging technique depended on the location of the TBR. If the lesion was proximal to the distal third of the trachea, a low-pressure, cuffed endotracheal tube was advanced as distal to the rupture as possible, nearing the main carina (simple bridging). The cuff was minimally inflated. Small air leaks were tolerated in order not to enlarge the TBR with an overinflated cuff. When the lesion involved the distal third of the trachea, or even the first centimeter of one mainstem bronchus, selective bilateral mainstem bronchus intubation with high-volume/low-pressure cuffed 6-mm endotracheal tubes was performed as described previously,[17] with the tubes passed through a large tracheostomy (Fig 1). Pneumothorax, extensive subcutaneous emphysema and mediastinal collections were drained as needed. All the patients underwent bronchoscopy at 6 months and 1 year.

Statistics

Demographic and descriptive data are given in means ± 1 SD. Comparisons between proportions were done using a Pearson χ^2 test or a Fisher exact test, when appropriate. Significant differences were considered at $p < 0.05$.

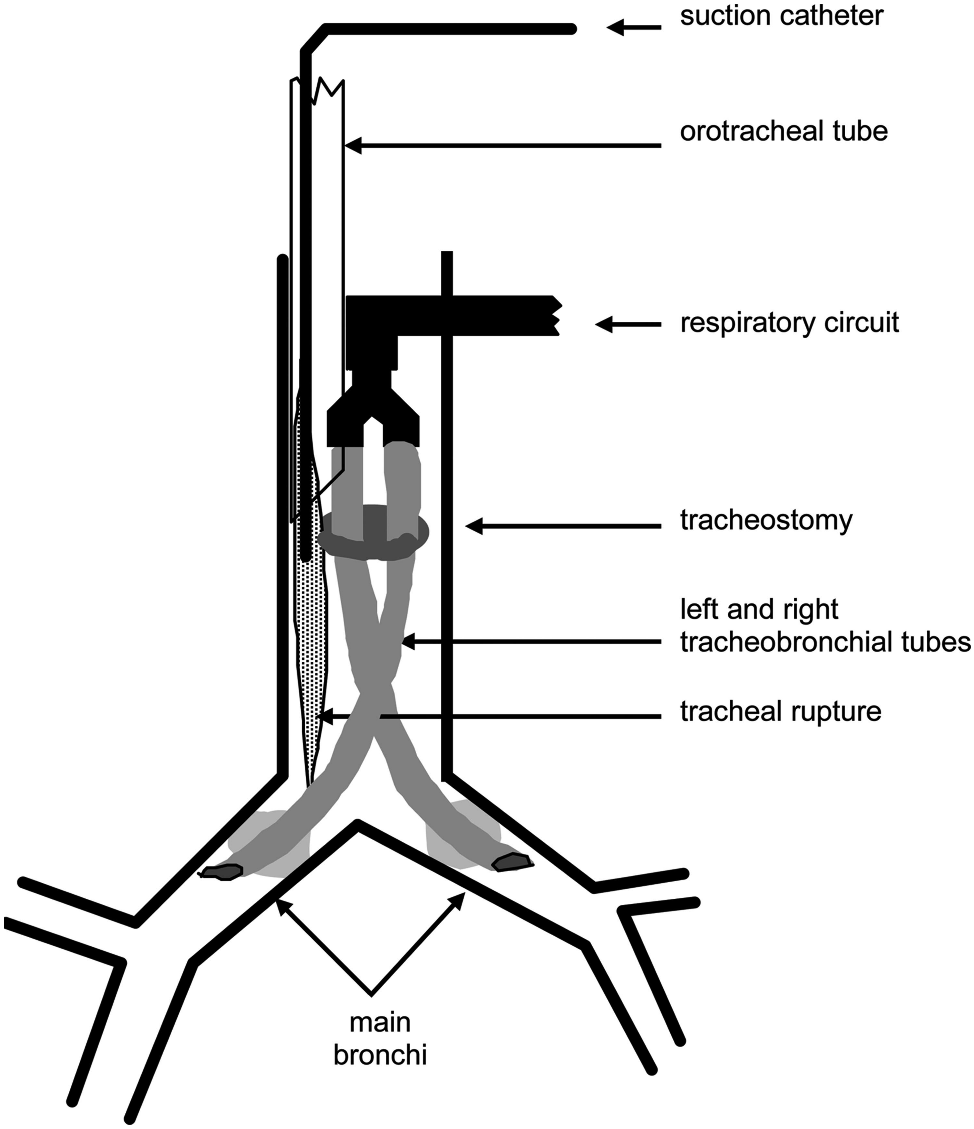

Figure 1. Selective mainstem bronchus intubation. Small low-pressure cuffed tubes are passed through a large tracheostomy and placed in each main bronchus. A large orotracheal tube was placed above the proximal end of the TBR to facilitate bronchoscopic follow-up, to allow ventilation in case of sudden obstruction of the small tubes and to allow continuous suction of secretions proximal to the distal cuffs.

Results

Thirty consecutive patients with TBR entered the study (26 women and 4 men; mean age, 63 ± 13.3 years; range, 31 to 79 years). All had undergone single-lumen tube endotracheal intubation for elective surgical operations (n = 16) or for emergency intubation for respiratory distress or cardiopulmonary resuscitation (n = 14). No patient was receiving long-term ventilation. Intubation was reported to be difficult in nine occasions, and a stylet was used in three occasions.

Subcutaneous emphysema was present in all but four patients, and pneumothorax was present in nine patients. Hemoptysis was the presenting sign in two patients. In two patients receiving mechanical ventilation, persistent air leak was the only clue suggestive of TBR.

All TBRs were longitudinal and located at the posterior membranous part of the trachea. Mean length was 4.5 ± 1.5 cm (range, 1 to 7.5 cm). Mean time from intubation to diagnosis was 12.5 ± 24.3 h (range, 1 to 120) [Table 1].

Fifteen patients were spontaneously breathing at time of diagnosis and underwent simple conservative management (patients 1 to 15; Table 1). The TBRs measured 3.85 ± 1.46 cm (range, 1 to 6 cm). Eight

Table 1—*Patient Characteristics, Bronchoscopic Findings, and Treatment Outcome**

Patient No.	Sex	Age, yr	Reason for Intubations	Body Mass Index, kg/m²	Difficult Intubation	Presenting Symptoms‡	Time to Diagnosis, h	Site§	TBR Length, cm	Mechanical Ventilation	Treatment‖	TBR Outcome
1	M	59	Mediastinoscopy	28.4	No	2,4,6	5	L	4	No	C	Success
2	F	79	Orthopedic surgery	21.3	No	2,3,6	7	M	2	No	C	Success
3	F	74	Colectomy	27.3	No	2,6	3	M+L	6	No	C	Success
4	F	71	Colectomy	29.4	No	2,3	3	M	3	No	C	Success
5	F	56	Thyroidectomy	17.3	No	2,4	2	L+C	5	No	C	Success
6	F	43	Internal saphenous stripping	19.8	No	2,4,6	4	M+L	4	No	C	Success
7	F	78	Orthopedic surgery	19.8	Yes	3,6	5	L	3	No	C	Success
8	F	50	Orthopedic surgery	18.8	No	2,3,4	3	M	4	No	C	Success
9	F	56	Internal saphenous stripping	25.3	No	2,4	3	M	5	No	C	Success
10	F	57	Umbilical hernia	27.2	No	2,9	6	L	3	No	C	Success
11	F	79	Cardiac arrest	21.5	No†	2,1	2	M+L	5	No	C	Success
12	F	31	Gynecologic surgery	NA	Yes	2,4	6	M	3	No	C	Success
13	F	76	Orthopedic surgery	28	No	2	3	M	2.5	No	C	Success
14	F	72	Mastectomy	28.1	No	2	6	M+L	6	No	C	Success
15	M	61	Mitral valve replacement	34.4	No	12	20	M	1	No	C	Success
16	F	52	Acute respiratory failure	34.3	Yes†	3	5	L	6	Yes	SV	Failure
17	F	78	Acute respiratory failure	24.7	No†	4	6	M+L	7	Yes	SV	Failure
18	M	78	Acute respiratory failure	33.5	No†	2,4	2	L	3	Yes	SV	Failure
19	F	64	Pulmonary edema and cardiac arrest	24.5	Yes†	2	5	L	5	Yes	SV	Success
20	F	70	Seizures	17.1	Yes†	1,2	24	M	3	Yes	SV	Success
21	F	53	Seizures	27.5	No†	1,10,11	72	M+L	6	Yes	SV	Success
22	F	59	Acute respiratory failure, angina	31.9	Yes†	2,1	6	M+L	7.5	Yes	SV	Success
23	F	48	Acute respiratory failure	58.8	Yes†	2	6	M+L	5	Yes	SV	Success
24	F	67	Acute respiratory failure	NA	No†	2	4	M+L	6	Yes	SV	Success
25	M	75	Colectomy	25.9	No	2,4,5	120	L+C	4	Yes	SV	Success
26	F	43	Subdural hemorrhage	25.4	Yes†	2,5,7	1	L+LMSB	1.5	Yes	SV	Success
27	F	77	Seizures	29.3	Yes†	1,2,8,11	6	L+RMSB	6	Yes	SV	Success
28	F	79	Orthopedic surgery	21.2	No	2,10,11	26	M+L+C	7	Yes	SV	Failure
29	F	47	Acute respiratory failure	NA	No	2	6	M+L	6.5	Yes	Surgery	Failure
30	F	69	Subdural hemorrhage	NA	No†	2,1	10	M+L	5	Yes	Surgery	Failure

*F = female; M = male; NA = not available.
†Emergency intubation.
‡1 = mediastinal emphysema; 2 = subcutaneous emphysema; 3 = hemoptysis; 4 = pneumothorax; 5 = respiratory failure; 6 = cervical pain; 7 = acute severe asthma; 8 = pneumoperitoneum; 9 = bronchospasm; 10 = uncontrolled air leak (in patient receiving mechanical ventilation); 11 = radiologic evidence of balloon overinflation; 12 = cough.
§L = lower third of trachea; M = middle third of trachea; C = carina; RMSB = right mainstem bronchus; LMSB = left mainstem bronchus.
‖C = conservative; SV = selective ventilation.

TBRs showed full-thickness rupture with frank anterior intraluminal protrusion of the esophagus (Fig 2). In three patients, mild respiratory distress led us to proceed to short-term NIV. In these patients, all TBRs healed without sequelae, and the patients were discharged after 13 ± 6 days (range, 6 to 30 days). No mortality was observed in this group (Fig 3).

Thirteen patients receiving mechanical ventilation were considered at high surgical risk. Underlying conditions in these patients included severe respiratory failure not related to TBR-induced air leaks (n = 9), coma complicating stroke (n = 2), and severe myocardial deficiency related to ongoing coronary ischemia (n = 2).

Five patients underwent simple bridging. Patients 16, 17, and 18 died. Two deaths, on day 7 and day 11 (hepatic coma and septic shock without mediastinitis, respectively), were considered as unrelated to the TBR. The third death occurred suddenly on day 3 after an acute episode of hypoxemia, so that an acute complication of the TBR cannot be excluded in this case. Patients 19 and 20 healed without sequelae and were discharged after 12 days and 35 days, respectively. The latter patient required transient drainage of a sterile mediastinal collection via cervical approach.

Six patients underwent double selective intubation, since the TBR involved the lower third of the

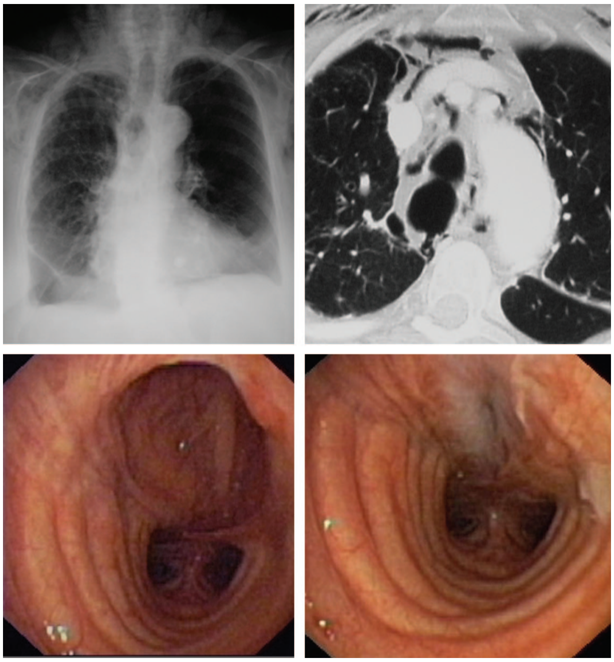

FIGURE 2. Shown are images from a 72-year-old woman receiving high-dose steroids (severe asthma) who underwent elective surgery (mastectomy). Massive subcutaneous cervical and mediastinal emphysema (*top left* and *top right*) led to diagnosis of a large full-thickness TBR of the mid and lower trachea (*bottom left*) while the patient was breathing spontaneously. Conservative management resulted in complete healing of the rupture 4 months later (*bottom right*).

trachea (patients 21 to 24), the carina (patient 25), or the left mainstem bronchus (patient 26). TBRs measured 5.25 ± 0.95 (range, 1.5 to 7.5 cm). All six patients had favorable outcome and were discharged alive after 45 ± 24 days (range, 20 to 76 days). Patient 21, however, required transient drainage of a sterile mediastinal collection via cervical approach on day 3. On day 38, an esophagotracheal fistula was found, which was treated sequentially (lower esophageal exclusion, followed by radical surgical closure of the fistula, and interposition of an intercostal muscular flap).

In the last two cases (patients 27 and 28), bridging the lesion was not possible due to extension of the TBR distal to the carina into the right main bronchus. Unilateral selective left lung ventilation was attempted in one patient without success. The other patient had her tube placed as distally as possible and received ventilation with low pressures (bilevel positive airway pressure and pressure support) while tolerating some air leaks. She was extubated on day 20 and discharged with completely healed TBR on day 35.

Two patients receiving mechanical ventilation underwent surgical repair by posterolateral thoracotomy. TBRs in these patients measured 5 cm and 6.5 cm, respectively. In patient 29, surgical repair was successful as judged by the absence of air leaks and by bronchoscopic findings. The patient died from massive GI hemorrhage on day 15 postoperatively. The last patient required mechanical ventilation because of severe aspiration pneumonia. Surgery was decided since mechanical ventilation was ineffective because of the importance of air leaks. The patient died 6 days postoperatively with refractory respiratory failure. Bronchoscopy showed partial dehiscence of the suture.

Overall mortality in this series was 20% (6 of 30 patients). Half of these deaths were unrelated to the TBR and were secondary to the underlying illnesses that lead to the need for endotracheal intubation. Among the 24 patients who survived, all were treated conservatively. Complete and spontaneous healing was usually observed within 1 month, except in three patients. Two patients receiving high-dose steroids showed delayed but complete healing (2 months and 4 months, respectively), and esophagotracheal fistula developed in a third patient, who required secondary surgical repair.

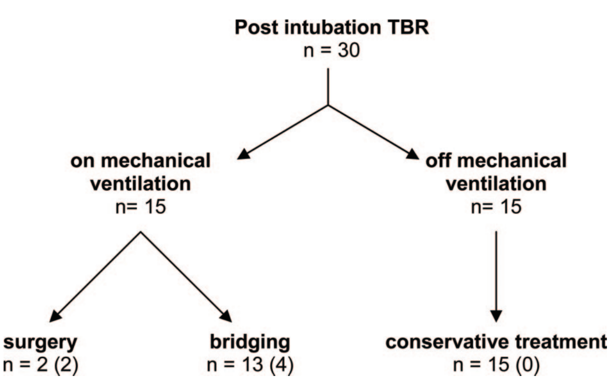

FIGURE 3. Treatment algorithm and outcome. The number of deaths is given in parentheses.

DISCUSSION

This study describes our experience in a series of 30 consecutive patients with iatrogenic tracheobronchial injuries. All but two patients were managed without direct repair of the rupture. More than three fourths of the patients, including those with large and full-thickness lacerations, recovered completely. The outcome in this series of patients compares favorably with data reported in the literature.[1–9,18,20,21]

Surgical repair has traditionally been considered as the cornerstone of therapy of iatrogenic TBR complicating intubation.[2–8] The stated purpose of surgical repair of TBR is threefold: First, surgical repair allows closure of the defect in order to allow effective ventilation. In patients requiring positive-pressure ventilation, major air leaks directly related to a TBR may compromise ventilation. In these patients, repair of the airway injury and pleural drainage immediately restores effective ventilation. In contrast, when a patient is extubated and breathes spontaneously, as it is the case in most patients with TBR complicating intubation for elective surgery, air leak is usually absent or is present during the first few days only when the patients cough. Provided pneumothorax and subcutaneous emphysema are properly drained, the consequences of TBR on the respiratory mechanics are usually minimal.[10,12,14,15] In the present series, three patients with full-thickness ruptures showed frank protrusion of the esophagus in the tracheal lumen that was responsible for an increase in respiratory workload. Pressure-controlled NIV applied for several days allowed us to overcome this problem. The situation is completely different when ongoing mechanical ventilation is required and the patient is not a candidate for surgical repair. This is usually the case when TBR complicates emergency intubation in unstable patients who require cardiopulmonary resuscitation for an acute event. In these patients, the only nonoperative means to restore effective ventilation when TBR-related air leaks are too important are to place the tip of the artificial positive pressure airway (tip of the endotracheal tube) distal to the rupture. Such "bridging of the lesions" was initially proposed as salvage therapy in patients who had ruptures proximal to the carina and who could not be operated.[11,13,15] Sixteen of 23 patients (69.6%) managed in this way in the literature[2–4,6,7,9,18,20,21] survived.

In the present series, TBR bridging was attempted as salvage therapy in 13 patients. Complete bridging was achieved in five patients by simply advancing the endotracheal tube distally. Separate endobronchial intubation was necessary in six patients with TBR too close to the carina. TBR bridging was effective in two thirds of the patients, which we consider promising, considering the context of salvage therapy. Not unexpectedly, among the four deaths, two were related to the underlying disease.

The second goal of surgical repair is to prevent mediastinitis secondary to contamination of the mediastinal structures from the nonsterile airways.[1–9,18,20] In contrast to esophageal perforations in which mediastinitis is a consistent finding, mediastinitis as a result of TBR has seldom been reported in the literature. Only two cases have been reported,[4,21] both in patients managed surgically. In the present series, only two cases of aseptic mediastinal collection were found by follow-up chest CT and were drained by simple cervical approach.

A third reason to consider surgical repair is the concern regarding healing complications and of potential long-term airway stenosis, especially in case of lengthy or full-thickness injuries. Delayed healing and especially secondary bronchial strictures have been reported in the very context of blunt tracheobronchial injuries.[22] It is noteworthy that tracheal stenosis resulting from TBR complicating intubation has been reported only twice. In one case, a patient initially managed nonoperatively acquired an asymptomatic stenosis[21]; in the other patient, the stenosis followed a surgically repaired TBR.[1] The mechanism of blunt tracheobronchial injuries and of iatrogenic TBR is very different and may explain these discrepancies.[23] None of the patients in the present series had a secondary stenosis. Healing delays were reported anecdotally in the literature[10,12,14,20] and usually vary between 2 weeks and 4 weeks. These findings are consistent with our findings. The length of the TBR as an indication for surgical management

Table 2—*Mortality According to the Indication for Intubation and According to Surgical vs Conservative Management**

Source	Elective Surgery		Emergency Intubation	
	Surgical Repair	Conservative Management	Surgical Repair	Conservative Management
Marty-Ane et al[2]	2 (1)	1	3 (1)	
Massard et al[3]	6	1	2	
Kaloud et al[4]	6 (1)		3 (1)	
Mussi et al[6]	7	1	1	
Meyer[7]	1		7 (5)	
Carbognani et al[9]	7	3		
Jougon et al[18]	3	7 (1)	1	1
Beiderlinden et al[20]				5 (2)
Gomez-Caro Andres et al[21]	1 (1)	11 (1)		6 (2)
Present series		16 (1)	2 (2)	12 (3)
Total	33 (3)	40 (3)	19 (9)	24 (7)

*Data are presented as No. (No. of deaths).

has been debated. Kaloud et al[4] recommended operating for any TBR lesion > 1 cm in length. Gabor et al,[24] in a case mix of iatrogenic and blunt tracheobronchial injuries, and Carbognani et al[9] in iatrogenic TBR recommended that ruptures > 2 cm in length be repaired. Jougon et al,[18] in contrast, proposed nonoperative management if the TBR was < 4 cm. Our findings are consistent with the data of Gomez-Caro et al,[21] who found that outcome was independent of the TBR length.

Recommendations regarding management of TBR complicating intubation have historically been based on experience with blunt tracheobronchial ruptures in which surgical repair is usually mandatory. Over the past 20 years, nonoperative management of TBR has been proposed for select patients in the following circumstances: stable vital signs, easy achievement of an adequate functional respiratory status under mechanical ventilation or in spontaneous ventilation, absence of esophageal injury, minimal mediastinal fluid collection, nonprogressive pneumomediastinum or subcutaneous emphysema, absence of sepsis, short ruptures, delayed diagnosis. In patients managed surgically, the initial indication for which the patient was intubated appears to play a crucial role in postoperative mortality. Including present data, three deaths were reported among the 33 patients (9%) with iatrogenic TBR who were intubated for elective surgery (Table 2). In contrast, the mortality is much higher (9 of 19 patients, 47%) among patients who underwent emergency intubation for an acute medicosurgical event ($p = 0.004$). This also holds true for conservatively managed patients in whom mortality was only 7.5% (3 of 40 patients) in case of scheduled surgery and 29% (7 of 23 patients) in case of emergency intubation ($p = 0.003$). Lastly, independent of the reason for intubation, there was a trend toward a higher mortality in surgically managed (12 of 52 patients) as compared with conservatively managed (10 of 64 patients) [23% and 16%, respectively; $p = 0.475$; Table 2].

These findings question the classical criteria for surgical repair. We recommend conservative nonoperative therapy as the best approach to postintubation TBR in patients who are breathing spontaneously, or when extubation is scheduled within 24 h from the time of diagnosis, or for patients who will require prolonged mechanical ventilation to treat their underlying respiratory status. Surgical repair should be reserved for patients in whom NIV or bridging the lesion is technically not feasible.

ACKNOWLEDGMENT: We are grateful to Alain Tremblay, MDCM, University of Calgary, Canada, for editorial assistance.

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