Review Article

Surgical treatment of bronchial rupture in blunt chest trauma: a review of literature

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Abstract: Bronchial rupture by blunt chest trauma is rare. We present a case of bronchial injury after blunt chest trauma that was repaired surgically by primary reconstruction. We performed a review of literature to verify if primary reconstruction is suitable for the treatment of adult patients with blunt bronchial injury. A systematic search was conducted to identify cohort studies of bronchial rupture after blunt chest trauma in adult patients between 1985 and 2016 (n=215 articles). Studies were included concerning four or more patients and in case patient data could be extracted. This resulted in 19 articles for final review, consisting of 155 patients. Mean age of 155 patients was 28 (range, 18–60) years. The main bronchus was mostly injured (81%), in 5% including an injury of the trachea and in 14% lobar bronchi injury. Surgical repair was performed in 95% of patients: primary anastomosis in 72%, pneumonectomy in 15%, lobectomy or sleeve resection in 12% and other in 1%. Perioperative mortality rate was 10%. Other complications occurred in 17% (empyema, rebleeding, stenosis and fistula, among others). Data concerning the occurrence of long-term complications or long-term follow-up was not found. Statistical evaluation could not be performed due to lack of consistent patient data. No strong recommendations regarding type and timing of surgery can be made based on the available literature. Based on our multidisciplinary opinion we would advocate primary anastomosis in case of stable vital signs with the goal to preserve healthy lung parenchyma. Moreover, it may be considered transferring these rare cases to an experienced thoracic and trauma surgery center.

Keywords: Bronchus; trauma; rupture; surgery; review

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Introduction

Case report

A 19-year-old male patient suffered a blunt trauma after a bicycle versus car collision late in the evening. The patient was dyspneic and had clinical signs of a left sided pneumothorax for which a chest tube was inserted by a specialized mobile medical trauma team. Further assessment showed a normal pulse and blood pressure and a maximal Glasgow coma score.

The patient was transferred to our hospital by helicopter. On presentation at our Accident and Emergency department, the patient was progressively dyspneic with clinical signs of a tension pneumothorax on the right side.

Figure 1 Computed tomography scan during initial assessment of the patient at the emergency department, in this coronal plane revealing subcutaneous emphysema, left sided pneumothorax and pneumomediastinum. Furthermore, a suggestion of a rupture of the left main bronchus can be seen.

A chest tube was inserted after which respiratory function improved. Because of a sudden drop in consciousness level, an orotracheal intubation with a single lumen tube was performed and mechanical ventilation was started.

Whole-body computerized tomography (CT) scan showed subdural and subarachnoid hematomas, subcutaneous emphysema, bilateral pneumothorax with pneumomediastinum, multiple spine fractures, an elbow luxation and a right-sided proximal first metacarpal fracture (*Figure 1*). The patient was taken to the operating theatre, where flexible bronchoscopy was performed and revealed a complete rupture of the left main bronchus, 3 cm distal of the carina (see *Figure 2*). Furthermore, the elbow joint was reduced, the open wounds on the left hand were debrided and an intracranial pressure sensor was inserted. Patient's vital signs remained normal and stable during surgery. After multidisciplinary consultation, it was decided to wait several hours and the patient was planned for surgery next day when a fit surgical team was available. The patient was admitted to the intensive care unit (ICU) pre-surgery.

The operation was performed under general anesthesia. The single lumen tube was uneventfully replaced by a double-lumen tube and a left-sided posterolateral thoracotomy was performed. After mediastinal dissection of pulmonary veins, main pulmonary artery and aortic arch, the completely transected left main bronchus was visualized.

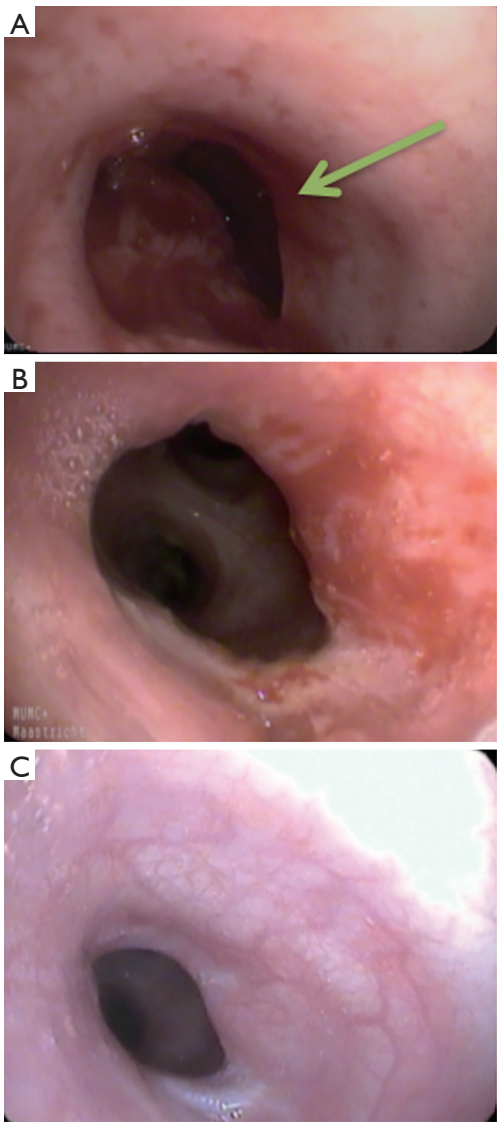

Figure 2 Bronchoscopy at diagnosis and during follow-up. (A) Bronchoscopy showing a complete rupture of the left main bronchus, 3 cm distal of the carina (arrow); (B) bronchoscopy 3 months after surgery. The left upper lobe and lower lobe were scaled as normal. The lumen of the distal left main bronchus was circular slightly narrowed (20% narrowing of lumen). Bronchial mucosa was still irritated and vulnerable; (C) bronchoscopy 9 months after surgery. A circular narrowing of 20% at the distal side of the left main bronchus was present. Bronchial mucosa was recovered with no mucosal defects or granulation tissue.

As seen on preoperative imaging, the bronchial rupture was localized approximately 3 cm distal to the carina. A tension-free primary end-to-end repair was performed with

Figure 3 The completely transected left main bronchus is visualized after mediastinal dissection of pulmonary veins, aortic arch and main pulmonary artery (1). A primary end-to-end repair with interrupted 3-0 polydioxanone sutures (PDS) was performed and visualized in this video.
Available online: http://www.asvide.com/article/view/27401

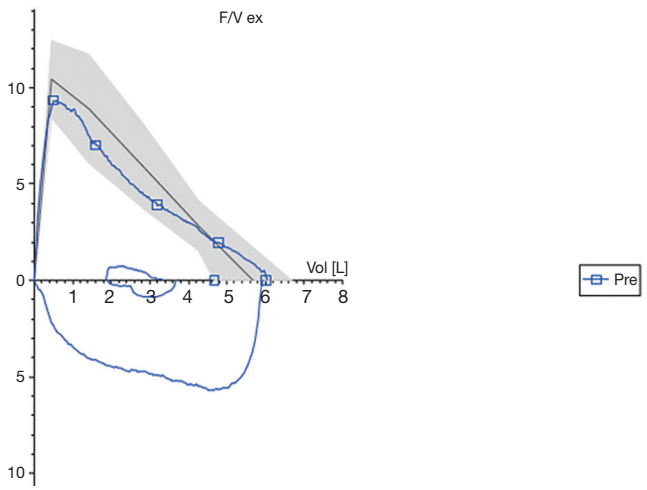

Figure 4 Flow-volume curve at 9 months of follow-up. Black line: normal curve; blue line: curve of patient's flow volume; X-axis: volume (L), Y-axis: flow (L/s).

Table 1 Pulmonary function (flow-volume) tests at 9 months of follow-up

Variable	Value	%pred
FEV_1	4.67 (L)	98
FVC	5.89 (L)	99
FEV_1/FVC	73%	
PEF	6.01 (L/s)	106

FEV_1, forced expired volume in one second; FVC, forced vital capacity; FEV_1/FVC, ratio; PEF, peak expiratory flow.

interrupted 3-0 polydioxanone sutures (PDS) (*Figure 3*). The anastomosis was covered with an intercostal muscle flap. Underwater testing showed no air leakage. A chest tube was placed and the thoracotomy was closed in layers. Operating time was 3 hours with a blood loss volume of 100 mL. After tube exchange to a single lumen tube, the patient was readmitted to the ICU.

Directly postoperative, an atelectasis of the left lung with respiratory deterioration occurred. After bronchoscopy and mechanical ventilation in prone position, respiratory condition improved. Right and left chest tubes were removed, respectively, on postoperative day 1 and 3. Patient was extubated on day 7 and discharged to the surgical ward on day 10. No complications occurred and the patient was discharged from hospital in favorable condition on day 19.

Bronchoscopy at 3 months follow-up showed the anastomosis with granulation tissue and non-significant stricture (*Figure 2B*). At 9 months follow-up, there were no residual complaints and pulmonary function was normal (*Figure 4*, *Table 1*). Bronchoscopy confirmed a patent anastomosis (*Figure 2C*). Patient had returned to his pre-injury functional status including physical activities and competitions as semi-professional cyclist.

Objective of the review

Bronchial injury after blunt trauma is rare (1–3%) but potentially life threatening and associated with a high mortality rate (2). Over 70–80% of the patients who sustain tracheal or bronchial injury die before arriving at the hospital, and therefore will stay unreported (3,4). In contrast, the majority of patients who survive until presentation at the hospital are managed non-operatively by supportive measures and chest tube thoracostomy. Only a minority of these patients will need urgent thoracotomy (5).

Bronchial injury has various clinical presentations ranging from lethal situations such as tension pneumothorax, persistent extensive subcutaneous emphysema, or conditions with fewer signs resulting in delay of diagnosis (6). Although bronchial injuries are rare, improved prehospital care has increased the number of patients presenting at the hospital. Familiarity in recognizing the condition and primary and final (surgical) management is therefore increasingly important.

In patients with blunt thoracic trauma, thoracotomy with pulmonary resection might be necessary in patients who are in respiratory extremis, according to a damage control strategy. Damage control surgery is aimed at life-preserving

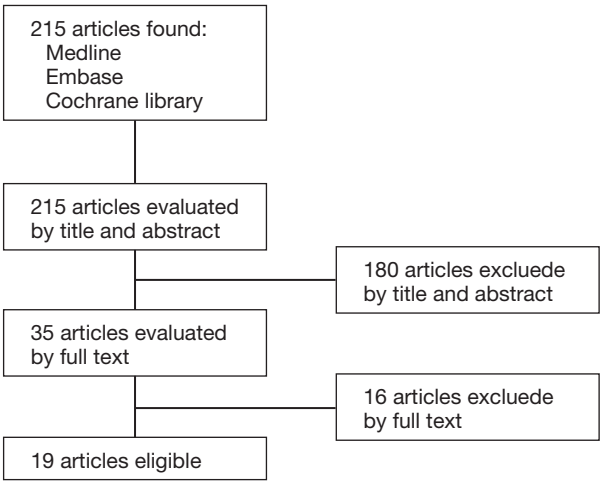

Figure 5 Flowchart of the selection of eligible articles.

procedures without extensive reconstruction. When vital signs are within limits, an alternative approach might include reconstruction of the bronchus in selected cases, with the aim to preserve lung parenchyma.

This review aims to assess the methods and results of surgical repair and short- and long-term follow-up in adult patients with bronchial injury after blunt chest trauma. We intent to provide important key points in the surgical management of bronchial rupture, a rare and potential life threatening injury.

Methods

This systematic review was performed according to PRISMA guidelines (7). A thorough review of literature was conducted to identify consecutive cohort studies reporting on blunt bronchial injuries in adult patients, published between 1985 and 2016. Medline, Cochrane Library and Embase were searched using the following keywords: bronchus; bronchial; blunt; trauma; and injury. The reference lists of included articles were also searched.

We limited the study to cohort studies reporting on patients with blunt bronchial traumatic injury aged 18 years or older. Studies reporting on penetrating trauma, iatrogenic injuries, children or solitary tracheal injuries were excluded.

Two authors independently performed the search and selection of articles (LvR; MvG). At first, articles were evaluated for eligibility based on title and abstract. Final evaluation and selection of articles was performed after article reading. In case of inconsistency in selection, we discussed these cases together with a third author (EdL) to make a final selection.

We collected information on mechanism of injury, time to diagnosis, anatomic location of injury, type of (surgical) repair, mortality and complications where available. Descriptive categorical data are presented as proportions and absolute numbers. Continuous variables are presented as means with standard deviations (SD). We performed a descriptive analysis, as it was not possible to undertake a meta-analysis due to the high level of heterogeneity of the interventions.

We assessed the risk of bias using the assessment tool of Cochrane Handbook for systematic reviews of interventions. Quality of the study methodology was assessed using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).

Results

The search resulted in 215 articles published between 1985 and 2016. A total of 180 articles were excluded based on title and abstract. Full text of the remaining 35 (5,8-23) articles (24-41) were evaluated and resulted in exclusion of another 16 articles, because it concerned review or survey articles, case reports, children, or only tracheal or penetrating injuries (5,8-12,17-20,22,26-28,32-34,36,38). Screening of the reference lists did not provide additional articles. So, final selection resulted in 19 articles that met the predefined inclusion criteria, as shown in *Figure 5*.

All studies were retrospective cohort studies. The 19 articles consisted of a total of 155 patients with blunt bronchial injury. Demographics and clinical characteristics of the patients are reported in *Table 2*. Their age ranged from 18 to 60 years, with a median of 28 years. Most injuries involved patients aged younger than 30 years (63%). The mechanism of injury involved a car accident in the majority of patients (60%), followed by motorcycle accidents in 16%. Other trauma included crush injury, fall from height, bicycle or pedestrian accidents.

The main bronchus was most frequently injured (n=125; 81%). The side of injury was documented in 90 of these patients, and showed that the right main bronchus was mostly affected, in 49 patients (32%). Injury of left main bronchus occurred in 36 patients (23%), and bilateral injury to both main bronchi occurred in 5 patients (3%). In 8 patients (5%), the main bronchus as well as the trachea was damaged. The remaining injuries concerned the lobar

Table 2 Patient demographics and clinical characteristics

Total	n	%
Age in years		
18–29	38	63
30–39	13	22
40+	9	15
Missing	95	
Cause of injury		
Car accident	53	60
Motorcycle accident	14	16
Fall from height	9	10
Crush injury	6	7
Pedestrian accident	5	6
Bicycle accident	1	1
Missing	67	
Site of injury		
Left main bronchus	36	23
Right main bronchus	49	32
Main bronchus side unknown	35	23
Bilateral main bronchi	5	3
Trachea and main bronchus	8	5
Main and lobar bronchus	3	2
Lobar bronchus	19	12

Table 3 Type of surgical treatment

Surgical treatment	n	%
Surgery		
Thoracotomy	148	95
Tracheostomy	1	1
No surgery	6	4
Type of repair in thoracotomy		
End-to-end anastomosis (sutured)	107	72
Lobectomy	14	9
Sleeve resection	4	3
Pneumonectomy	22	15
Intercostal flap repair	1	1

bronchi with or without damage to the main bronchus, in 22 patients (14%).

The time between trauma and surgical treatment was described in 54% of the cases (n=84). With available data, median time to surgical treatment was 7 days, with a range between zero days and 8 years (only one patient had this delay, unknown cause). Delayed treatment was caused by delayed presentation or diagnosis, transportation to other hospitals, or after failure of conservative treatment.

Surgical repair was performed in 95% of patients. The surgical approach was thoracotomy in all cases. In 72% of the cases, a sutured end-to-end anastomosis was performed, pneumonectomy in 15% and lobectomy in 9%. Other techniques included a sleeve resection, or repair by using an intercostal flap technique (*Table 3*). Conservative treatment consisted of long term chest tube thoracostomy. One patient died prior to surgery due to failure to establish patent airway.

In the study population, the duration of follow-up is unknown and there is also no information on the use of any specific evaluation methods like pulmonary function or bronchoscopy. Data on the occurrence of perioperative complications was provided in only 107 of 155 patients. The mortality rate was 10% and other complications occurred in 17% (e.g., stenosis, empyema, rebleeding, bronchopleural fistula) (*Table 4*).

Discussion

We presented a case of bronchial injury after blunt chest trauma that was repaired surgically by primary reconstruction and subsequently performed a thorough follow-up. Since these injuries are rare, we performed a review of literature to verify if primary reconstruction is suitable for the treatment of adult patients with blunt bronchial injury.

Blunt bronchial injury comes with a variation in presentation and severity (11,42,43). The main bronchus seems to be affected most frequently, and was in many cases accompanied by severe damage to lung tissue (43). These anatomical differences lead to diverse presentations, which might explain the delay in diagnosis and surgical treatment as discussed in this paper. In the majority of reported cases, there was no reason for an acute procedure. Median time to surgery after injury was 7 days, and still a substantial number of patients underwent surgery even at a later

Table 4 Perioperative complications

Complications	n	%
Mortality rate	16	10
Unknown cause	10	
Multiple organ failure	2	
Other traumatic injury	2	
Cardiac arrest	1	
No patent airway	1	
Complications	26	17
Stenosis	9	
Empyema	5	
Pulmonary hypertension	3	
Persistent air leakage	2	
Nerve injury	2	
Dyspnoea during mild exercise	2	
Wound infection	1	
Bronchopleural fistula	1	
Rebleeding	1	

moment. Appropriate timing until surgery is debatable and can be managed best based on patients' health status, injury characteristics, and expertise of hospital and surgical team. Our case presented in the evening and had stable vital signs, so the multidisciplinary team of trauma surgeon, thoracic surgeons, pulmonologist and intensivist, decided there was no need for damage control surgery and postponed surgery until the next morning. The favorable outcome of our patient supports the decision to postpone surgery. Even in patients with complete transection, adequate lung ventilation is possible in the majority of cases because usually only a small gap exists between the two ends of the ruptured bronchus, with coverage of surrounding tissues (24).

The type of surgical treatment in blunt bronchial injury depends among others on the site and extent of the damage. In this review, bronchial rupture occurred more often in the right compared to the left main bronchus (32% *vs.* 23%). A study of Altinok *et al.* commented that this is probably caused by the right main bronchus being shorter and less protected by large surrounding fixed vascular structures, and by a larger volume of the right lung (44).

In 72% of the patients, an end-to-end anastomosis was created, which seems feasible and should be considered in most cases to preserve (healthy) lung parenchyma, in this generally young patient population. Even in older patients this should be considered, since they are more often confronted with pulmonary diseases such as chronic obstructive pulmonary disease (COPD). In contrast to complete bronchial rupture, it is arguable whether smaller defects, that comprise less than the circumferential one third of the main bronchus, can be treated conservatively (43). A paper of Kiser *et al.* showed that the mortality risk is higher for patients who were conservatively treated (25% *vs.* 3%), but might be biased by other patient- and injury related characteristics (23). Failure of conservative treatment during follow-up can present by bronchial stenosis or fistulas, although no exact numbers are available on this issue. Surgical treatment can of course lead to complications like bronchial stenosis that was present in 6% of the reviewed population.

Several limitations of this analysis should be discussed. The objectives of our study were, among others, to estimate the morbidity and mortality risk in surgical treatment of blunt bronchial rupture. These outcome measures were however, insufficiently described in the studies included this review. Follow-up data was even completely missing in 31% of the patients and information on follow-up duration per patient was unknown. Reconstructions of bronchial ruptures with primary repair are mainly at risk for anastomotic complications, like stenosis. The case described in this review had favorable follow-up results with no signs of clinical significant stenosis during bronchoscopy even after nine months of follow-up. This could be related to preservation of local circulation.

Furthermore, morbidity and mortality rates are biased in the studies available, partly due to over- as well as under-reporting. Registration of morbidity and mortality is challenging since many patients will be referred patients from other hospitals in a different region, and those are not likely to attend to any follow-up appointments. Furthermore, the complication rate is also biased by concomitant injuries and comorbidity. Unfortunately, we could not report on this topic due to missing data in the included studies on concomitant injuries or injury severity score.

Another limitation could be that we decided to exclude case reports and thus valuable information about this rare condition could have been lost. However, small studies with unfavorable results are unlikely to be published and therefore we believe that excluding those reports is a more correct approach to the analyses.

Conclusions

Blunt bronchial rupture mostly occurs in younger trauma patients and is associated with high morbidity and mortality rates. No strong recommendations regarding type and timing of surgery can be made based on the available literature. Based on our multidisciplinary opinion we would advocate primary anastomosis in case of stable vital signs with the goal to preserve healthy lung parenchyma. Moreover, it may be considered transferring these rare cases of bronchial rupture to an experienced thoracic and trauma surgery center.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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