Original Article

Factors determining surgical outcome after bronchial re-implantation for traumatic main bronchus transection

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ABSTRACT

Objectives: The diagnosis of traumatic transection of main bronchus is often delayed, resulting in attempts at surgical repair sometimes even months after the injury. Our aim is to analyze the factors affecting surgical outcome in patients undergoing lung preserving bronchial re-implantation for bronchial transection. **Materials and Methods:** This is a retrospective analysis of prospectively maintained data of 10 cases of traumatic transection of main bronchus who underwent bronchial re-implantation at a tertiary thoracic surgery center in India. Patients were divided into two groups based on their total length of hospital stay. Occurrence of postoperative complications and/or hospital stay >7 days were considered poor surgical outcomes. **Results:** Out of 10 patients, 6 were left main bronchus transections and 4 right main bronchus transections. The male-female ratio was 7:3. Right-sided bronchial injury and higher preoperative Injury Severity Score (ISS) were associated with poor surgical outcomes ($P < 0.01$). These patients also had significantly higher anastomotic complications, chest tube duration, and prolonged postoperative air leak. Age of the patient, preoperative hemoglobin or albumin levels, and time of referral did not influence the surgical outcomes. **Conclusions:** Poorer surgical outcomes were observed in patients who had right-sided main bronchus injury and higher ISSs. Time of referral did not influence the outcome. This study is limited by small sample size and retrospective nature. As no single center will have large numbers of this uncommon injury, multicenter pooled data are needed to re-affirm the findings of this study.

KEY WORDS: Surgical outcomes, surgical repair, traumatic bronchus transaction

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INTRODUCTION

Bronchial injuries are rare, yet life-threatening situations secondary to either blunt or penetrating trauma. They pose a significant diagnostic challenge for clinicians and require a high index of suspicion for timely diagnosis, especially after blunt thoracic trauma.[1] Traumatic bronchial injuries present with clinical features such as tachypnea, tachycardia, dyspnea, pneumothorax, pneumomediastinum, and subcutaneous emphysema. Very often, blunt thoracic trauma can be associated with multiple rib fractures, pulmonary parenchymal contusion, or laceration which will have similar symptoms and signs. These clinical features can easily misguide clinicians in the diagnosis of bronchial injury.[2,3] In addition, these patients may also have other body system injuries which may further increase the possibility of delayed/missed diagnoses.[4] Hence, it is common for these patients to

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present to thoracic surgeon weeks, months, or even years after primary trauma. Appropriate management of bronchial injuries depends on its exact site and extent. The management becomes even more challenging in setting of chronic posttraumatic bronchial stenosis, as delayed presentation is associated with higher chances of parenchymal resection and poorer surgical outcomes.[5] Surgical procedures needed for these patients may range from primary repair of bronchial injury, end-to-end anastomosis of transected ends, and sleeve resection of bronchus to lobectomy or pneumonectomy depending on the per-operative findings.[6] This study aims at presenting surgical management of such complex injuries to analyze the factors influencing the surgical outcomes.

MATERIALS AND METHODS

This is a retrospective analysis of a prospectively maintained database of cases operated for traumatic main bronchus transection in a tertiary care center, New Delhi, India, from March 2012 to 2020. Institutional ethics committee approval was sought. Patients who underwent bronchial re-implantation for traumatic transection were included in the study. Demographic data and details of present illness including mechanism of injury were recorded in detail.

Patients presenting with a history of acute respiratory distress after blunt chest trauma were stabilized as per the ATLS protocol. Chest tube insertion was done on an emergency basis based on clinical primary survey or on detection of pneumothorax/hemothorax on imaging. Once the patient was stabilized, he/she was subjected to computed tomography (CT) chest to assess airway, lung, mediastinum, and rib cage. Massive and persistent air leaks in the intercostal drain (ICD), rapidly progressing subcutaneous emphysema, presence of pneumomediastinum, failure of collapsed lung to expand after chest tube placement, and presence of any doubtful features of airway injury in CT scan were considered as criteria for "suspicious cases" for airway injury. Detailed examination of tracheobronchial tree was done through flexible bronchoscopy where exact site as well as extent of injury, if present, was documented. The presence of bronchial transection with collapsed lung was the indication for surgery.

In case of delayed presentation, the time until diagnosis was recorded and all patients underwent a detailed clinical examination. Contrast-enhanced CT of the chest was performed to assess the extent of bronchial injury and viability of underlying lung parenchyma. Flexible bronchoscopic examination was done, and the tracheobronchial tree was inspected thoroughly in all cases to document the site of injury, distance of injury from carina, and extent of injury. Indications for surgery were presence of severe stenosis with collapsed lung, symptoms like persistent cough, recurrent suppurative expectoration, as well as dyspnea.

Surgical details

All the procedures were performed under general anesthesia with single lung ventilation. This was achieved either with a double-lumen tube or by inserting a small-sized single lumen tube into uninvolved bronchus under bronchoscopic guidance. Patients were placed in lateral decubitus position with involved side up. Posterolateral thoracotomy was the surgical approach of choice. As most of our cases had delayed presentation with collapsed lung, the lung was always carefully assessed for its viability. After ensuring that the lung parenchyma is viable, the both transected ends of the injured bronchus were identified, cut open and edges freshened. An end-to-end tension-free anastomosis was done using 3-0 PDS suture. Various scenarios of anastomosis are illustrated in Figures 1-3. Anastomosis was reinforced with pericardial fat/intercostal muscle flap on the right side, whereas no flap cover was used on the left side. Lung expansion was checked, and airtightness of the anastomosis was ensured. Two chest drains were placed and connected to Thopaz™ digital negative suction device (Medela, Switzerland), with a negative pressure of 20 cm of H2O. Patients were extubated on the table whenever possible, monitored in the recovery room overnight, and shifted to floor the next morning. Patients who required ventilation were kept in intensive care unit till they were extubated and then shifted to high dependency unit for further observation and transferred to ward once stabilized.

Supervised, vigorous chest physiotherapy along with adequate nutritional support was continued to maintain good lung expansion. The chest drains were removed when there was no air leak, and the drainage was not purulent/hemorrhagic and <100 ml in 24 h. Patients were discharged from hospital either after drain removal or with drains if they had prolonged drainage or air leak. Duration of postoperative air leak (>7 days), duration of chest tube, hospital stay, anastomotic dehiscence, wound infection, and other complications during hospital stay were monitored and recorded. Occurrence of any postoperative complication and/or hospital stay >7 days was defined as poor surgical outcome. After discharge, patients were monitored to check for status of lung expansion and any other complication. Follow-up was done on an outpatient basis at the 1st week after discharge and every month thereafter for 6 months. All patients had a chest X-ray at 6 months to assess the status of lung expansion. Check bronchoscopy was performed at 3 months and at 1 year after surgery to evaluate the anastomosis.

Statistical analysis

Statistical testing was conducted with the Statistical Package for the Social Sciences system version SPSS 17.0 (IBM SPSS [Statistical Package for the Social Sciences] Statistics for Windows, version 21 [IBM Corp., Armonk, N.Y., USA]). Continuous variables were presented as mean ± standard deviation or median (interquartile range). Categorical variables were expressed as frequencies and percentages. The comparison of normally distributed

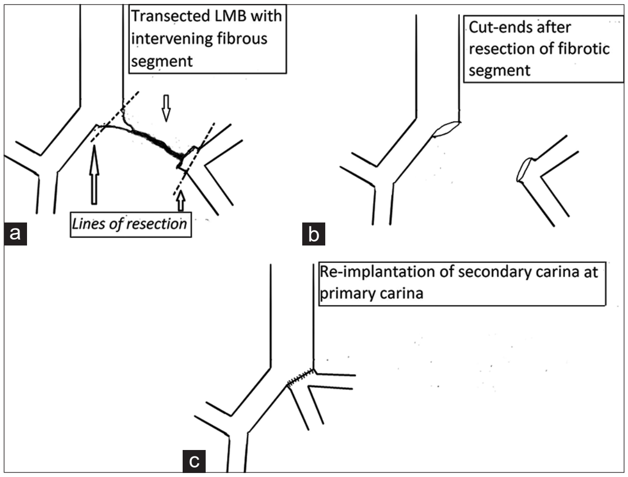

Figure 1: (a) Transected Left Main Bronchus with intervening fibrous tissue, (b) Cut-ends after resection of fibrotic segment, (c) Re-implantation of secondary carina at primary carina

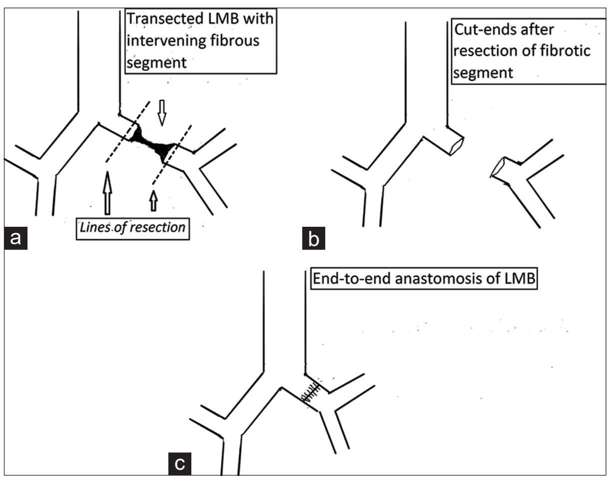

Figure 2: (a) Transected Left main bronchus with intervening fibrous tissue, (b) Cut-ends after resection of fibrotic tissue, (c) End-to-end anastomosis of left main bronchus

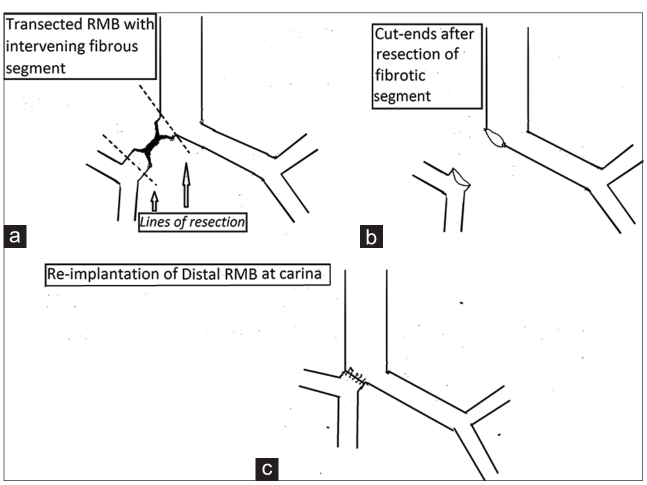

Figure 3: (a) Transected right main bronchus with intervening fibrous tissue, (b) Cut-ends after resection of fibrotic segment, (c) Re-implantation of distal right main bronchus at carina

continuous variables between the groups was performed using Student's *t*-test. Nominal categorical data between the groups were compared using Chi-squared test or Fisher's exact test as appropriate. Nonnormal distribution continuous variables were compared using Mann–Whitney U-test. For all statistical tests, $P < 0.05$ was taken to indicate a significant difference.

RESULTS

Demography and preoperative variables

A total of 12 patients with traumatic main bronchus transection were treated in our center during the study period. Out of these, 1 patient who underwent primary repair of left main bronchus (LMB) rupture and another patient who had right pneumonectomy were excluded and the remaining 10 patients who had bronchial re-implantation were included in the study. These patients were predominantly males (70%) in the age group of 21–32 years, with a median age of 25. The median referral time from injury was 1.7 months. The shortest referral was 1 day and longest was 5 months. Majority of the patients had LMB injury (60%). Detailed demographics are presented in Table 1.

Perioperative variables

Posterolateral thoracotomy was the surgical approach of choice. For right main bronchus (RMB) injury, right posterolateral thoracotomy was used and vice versa. In acute setting, the margins of the cut end of the transected bronchus were freshened up to healthy edges to achieve an end-to-end anastomosis between healthy margins. In delayed cases, due to dense adhesions and scar tissue, identifying the transected bronchial ends was challenging. Intraoperative bronchoscopy was employed to help locate the proximal end of injured bronchus. A sleeve of injured and cicatrized bronchus was resected and fresh ends were joined by an end-to-end tension-free anastomosis. Evaluation of exact location of injury showed that transection occurred at or within 1 cm of the carina in 5 (50%), within 2 cm of the carina in 3 (30%) and within 4 cm of the carina in 2 (20%) patients. The average distance between the site of injury and carina was shorter for right bronchial injuries than for left bronchial injuries (0.5 cm versus 2.5 cm). In cases of RMB transection, freshened margin of RMB was re-implanted directly over the carina in all cases due to the proximity of the injury to the carina. However, only in half of the cases of LMB injury, there was a need to anastomose LMB over the carina. In the remaining half, an end-to-end anastomosis of LMB margins was done. Three patients were electively intubated immediately after surgery and were extubated on postoperative day 2. All postoperative complications occurred in 3 patients. Anastomotic complications in these patients were managed conservatively without need for re-exploration. Details about postoperative complications are mentioned in Table 2.

Factors affecting surgical outcomes

Surgical outcomes were poorer in patients who had right-side main bronchus injury ($P = 0.03$) and those with higher Injury Severity Score (ISS) ($P < 0.001$). Time of referral did not influence the outcomes ($P = 0.8$) [Table 3].

DISCUSSION

Tracheobronchial injuries contribute 0.5%–2% of all cervicothoracic trauma, including immediate mortality.[7]

Table 1: Overall demographic details (*n*=10)

Characteristics	Frequency
Male, *n* (%)	7 (70)
Female, *n* (%)	3 (30)
Age (years), mean±SD	25.2±5.6
Body mass index (in kg/m^2), mean±SD	21.4±2.8
Median referral time (in months), IQR	1.7 (1.1- 4.8)
Side of main bronchus involved (%)	
Right	4 (40)
Left	6 (60)
ISS immediately after accident, mean±SD	41±2
Preoperative hemoglobin (in g/dl), mean±SD	12.9±1.7
Preoperative albumin (in g/dl), mean±SD	3.4±1.4

ISS: Injury Severity Score, SD: Standard deviation, IQR: Interquartile range

Table 2: Perioperative details

Characteristics	Frequency (%)
Surgical approach	
Right posterolateral thoracotomy	4 (40)
Left posterolateral thoracotomy	6 (60)
Location of injury	
RMB transected just at carina	2
RMB transected 1 cm beyond carina	2
LMB transected 1 cm beyond carina	1
LMB transected 2 cm beyond carina	3
LMB transected 4 cm beyond carina	2
Type of reconstruction	
RMB re-implanted over carina	4 (40)
LMB re-implanted over carina	3 (30)
Sleeve resection and end-to-end anastomosis of LMB	3 (30)
Operative time (min), mean±SD	192±92
Mean blood loss (in ml), mean±SD	235±110
Required elective postoperative mechanical ventilation	3 (30)
Duration of ICD (in days), mean±SD	6.9±4.8
Postoperative complications	
Anastomotic complications	3
Surgical site infection	1
Lung atelectasis	1
Prolonged air leak (>7 days)	3
Mortality	0

RMB: Right main bronchus, LMB: Left main bronchus, ICD: Intercostal drain, SD: Standard deviation

Small noncircumferential injuries, which are clinically insignificant, may never come to the attention of the physicians and heal spontaneously. However, massive injuries lead to significant long-term consequences. Traumatic bronchial injury due to blunt trauma can present with tension pneumothorax, persistent extensive subcutaneous emphysema, or progressive mediastinal emphysema.[8] 50%–80% of the patients with significant injury may be missed and have delayed presentations (>24–48 h).[9,10] In our series, 90% of the cases had delayed presentation. After complete bronchial transection, peribronchial tissue and intact pleura can form a false passage, especially on the left side. This may allow continued ventilation beyond the site of bronchial injury at least temporarily, thus giving an impression of complete lung expansion after ICD insertion.[11] Eventually, the lung collapses raising the possibility of bronchial injury. Furthermore, rarity of these injuries and lack of familiarity in managing such cases contribute to the delayed diagnosis.[12] Therefore, a high index of suspicion is required to diagnose such injuries in time.

Literature review suggests more frequent involvement of RMB probably due to shorter length of RMB and heavier right lung causing more traction on RMB at the time of injury. LMB is relatively better protected due to longer mediastinal course and protection by major fixed vascular structures on all sides.[13] However, in our series, LMB was more frequently involved than right. The average distance of bronchial injury from the carina was longer for left bronchial injuries, may be due to the longer length of the left bronchus compared with the right one. Previous series also reported a similar finding.[14] A patient with suspected bronchial injury should undergo a CT chest and bronchoscopy for diagnosis and localization of the injury. CT scan has sensitivity of over 90% for tracheobronchial injury after blunt thoracic trauma.[15] However, CT scan cannot replace the bronchoscopy. Flexible bronchoscopy is the fastest, most effective, and easily available technique to diagnose tracheobronchial injury, which provides accurate diagnosis, and also the location and extent of severity of the injury.[7,16,17]

Partial bronchial transections with fully expanded lungs can be managed conservatively with successful outcome, although some of them do develop bronchial stenosis at the site of injury, requiring interventions later. However, bronchial transection with collapsed ipsilateral lung is an

Table 3: Factors affecting surgical outcomes

Variables	Poor surgical outcomes (*n*=3)	Good surgical outcomes (*n*=7)	*P*
Age, mean±SD	26.3±5.3	24.6±5.1	0.6
Right-sided bronchial injury	3	1	0.03
Left-sided bronchial injury	0	6	
Referral time (in months), mean±SD	1.6±2.8	1.8±1.4	0.8
ISS score, mean±SD	44±2	35±1	<0.001
Preoperative hemoglobin, mean±SD	12.4±1.9	13.3±1.6	0.4
Preoperative albumin, mean±SD	3.5±1.3	3.7±1.1	0.8

ISS: Injury Severity Score, SD: Standard deviation absolute indication for immediate surgical intervention. Surgical approach is decided by the location and the side of the injury. Posterolateral thoracotomy on the affected side is the standard surgical approach, and all patients should have double-lumen tube for lung isolation. Carina can be approached from the right side also, which means that proximal most LMB injuries can be accessed and repaired by right thoracotomy. However, this is applicable only in acute presentations where we need to access the carina and proximal LMB and create an anastomosis between the two, which can be done through right thoracotomy. In old injuries with collapsed lung, as was the case with majority of our patients, one needs to mobilize and assess the lung for its viability. This is possible only through left thoracotomy, which we did in all our cases. The access to carina from left thoracotomy does become an issue due to aorta coming in the way. We overcame this challenge by looping the proximal descending aorta using cotton slings and pulling it away from the mediastinum, thereby increasing the space and visibility in the carinal area for a safe anastomosis under vision.

Acute bronchial transections are easier to manage surgically as all that they require is to freshen the margins and anastomose end to end. Chronic cases, on the other hand, are challenging because first and foremost, the fibrosed and occluded bronchial ends need to be identified as they lie buried in the scar tissue. The proximal end often retracts toward the carina. Intraoperative bronchoscopy, with light shining through the bronchial stump, helps in identifying the proximal stump. The distal stump often retracts into the lung tissue. The identified bronchial ends are cut open, complete mucous clearance was done, and the cut edges are freshened. Viability of the lung parenchyma is checked again and any bronchiectatic segment, if present, is resected. An end-to-end anastomosis is now performed with 3-0 PDS sutures. In natural course of such injuries, the transected bronchus gets occluded in 2–6 weeks' time by granulation tissue, which prevents air exchange. Some patients, however, may have incomplete occlusion, i.e., stenosis permitting some airflow which leads to postobstructive pneumonia and subsequent bronchiectasis and destruction of functional lung tissue. However, in cases of complete occlusion, the airway gets filled with mucus which possibly prevents and protects from infection. Hence, the probability of restoration of physiological functions is better in completely occluded bronchus than incompletely occluded bronchus.[18-20] This may explain the preservation of lung in our cases. There are reports of successful repair and preservation of lung parenchyma even 20 years after bronchial injury.[21,22]

Anastomotic complications happened in three of our patients, all in RMB injury. One of them was already operated elsewhere, where initial surgery was improperly done. After re-repair at our center, this patient had partial anastomotic dehiscence, mediastinitis, and septicemia for which self-expanding metallic Y-stent insertion was inserted along with prolonged mechanical ventilation and parenteral antibiotics. She recovered in due course and stent was removed 3 months later. All anastomotic complications were managed conservatively without need for re-exploration. Possible explanation for higher anastomotic complications on the right side could be vascular insufficiency of bronchial margins because of blood supply by single bronchial artery on the right side. Prolonged air leak (>7 days) occurred in 30% of the patients, and all of them were alveolopleural leaks because of extensive adhesiolysis of the lung parenchyma. All these patients required prolonged negative suction through ICDs. One of these patients had postoperative incomplete lung expansion, for which a new ICD was inserted, following which the lung completely expanded. A recent systematic review analyzed 19 articles consisting of 155 patients of tracheobronchial injuries due to blunt trauma and showed a 17% overall postoperative complication rate ranging from anastomotic stenosis, empyema thoracis, persistent air leak to bronchopleural fistula.[23] Right-sided bronchial injury and higher ISS significantly affected the surgical outcomes.

CONCLUSIONS

Bronchial transection secondary to blunt thoracic trauma may mimic other associated clinical conditions and can be missed in the acute phase leading to late presentation. It requires a high degree of clinical suspicion for prompt diagnosis. Bronchoscopy is the diagnostic modality of choice for evaluating suspected bronchial injuries. Surgical management with lung preservation appears to be safe and feasible with acceptable perioperative outcomes. Right-sided bronchial injury and higher ISS significantly affect the surgical outcomes. These patients are likely to have higher anastomotic complications and prolonged postoperative air leak. Delayed referral did not influence the surgical outcomes. Small sample size and retrospective nature were the major limiting factors of this study. Pooled data from many centers with larger number of patients and longer follow-up are suggested for further confirmation of our results.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Glazer ES, Meyerson SL. Delayed presentation and treatment of tracheobronchial injuries due to blunt trauma. J Surg Educ 2008;65:302-8.
2. Balci AE, Eren N, Eren S, Ulkü R. Surgical treatment of post-traumatic tracheobronchial injuries: 14-year experience. Eur J Cardiothorac Surg 2002;22:984-9.
3. Ayed AK, Al-Shawaf E. Diagnosis and treatment of traumatic intrathoracic major bronchial disruption. Injury 2004;35:494-9.
4. Kiser AC, O'Brien SM, Detterbeck FC. Blunt tracheobronchial injuries: Treatment and outcomes. Ann Thorac Surg 2001;71:2059-65.
5. Chu CP, Chen PP. Tracheobronchial injury secondary to blunt chest trauma: Diagnosis and management. Anaesth Intensive Care 2002;30:145-52.

6. Altinok T, Can A. Management of tracheobronchial injuries. Eurasian J Med 2014;46:209-15.
7. Karmy-Jones R, Wood DE. Traumatic injury to the trachea and bronchus. Thorac Surg Clin 2007;17:35-46.
8. Bertelsen S, Howitz P. Injuries of the trachea and bronchi. Thorax 1972;27:188-94.
9. Richardson JD. Outcome of tracheobronchial injuries: A long-term perspective. J Trauma 2004;56:30-6.
10. Chen D, Han L, Hu Y, Yin H, Zhao H, Li H. Diagnosis and treatment of bronchial rupture from blunt thoracic trauma. Chin Med J (Engl) 2001;114:540-1.
11. Taskinen SO, Salo JA, Halttunen PE, Sovijärvi AR. Tracheobronchial rupture due to blunt chest trauma: A follow-up study. Ann Thorac Surg 1989;48:846-9.
12. Angood PB, Attia EL, Brown RA, Mulder DS. Extrinsic civilian trauma to the larynx and cervical trachea Important predictors of long-term morbidity. J Trauma 1986;26:869-73.
13. Mihos PT, Potaris K, Gakidis I, Myrianthefs PM, Baltopoulos GJ. Clear-cut complete rupture of origin of right main bronchus. Asian Cardiovasc Thorac Ann 2008;16:65-7.
14. Alawady TS, Abdeislam AH, Badawi MW. Early and late management of non-penetrating traumatic thoracic tracheobronchial injuries. AAMJ 2013;11:190-212.
15. Rieley RD, Miller PR, Meridith JW. Injury to esophagus, trachea and bronchus. In: Moore EJ, Feliciano DV, Mattox KL, editors. Trauma. New York: Mc Graw-Hill, Medical Pub Division; 2004. p. 544-7.
16. Wintermark M, Schnyder P, Wicky S. Blunt traumatic rupture of a mainstem bronchus: Spiral CT demonstration of the "fallen lung" sign. Eur Radiol 2001;11:409-11.
17. Rico FR, Cheng JD, Gestring ML, Piotrowski ES. Mechanical ventilation strategies in massive chest trauma. Crit Care Clin 2007;23:299-315.
18. Hwang JJ, Kim YJ, Cho HM, Lee TY. Traumatic tracheobronchial injury: Delayed diagnosis and treatment outcome. Korean J Thorac Cardiovasc Surg 2013;46:197-201.
19. Burke JF. Early diagnosis of traumatic rupture of the bronchus. JAMA 1962;181:682-6.
20. Juvekar NM, Deshpande SS, Nadkarni A, Kanitkar S. Perioperative management of tracheobronchial injury following blunt trauma. Ann Card Anaesth 2013;16:140-3.
21. Ozdulger A, Cetin G, Gulhan E, Topcu S, Tastepe I, Kaya S. A review of 24 patients with bronchial ruptures: Is delay in diagnosis more common in children? Eur J Cardiothorac Surg 2002;23:379-83.
22. Sakiyalak P, Vigneswaran WT. Successful late restoration of traumatic distal bronchial separation. Int Surg 2004;89:195-7.
23. van Roozendaal LM, van Gool MH, Sprooten RT, Maesen BA, Poeze M, Hulsewe KW, *et al*. Surgical treatment of bronchial rupture in blunt chest trauma: A review of literature. J Thorac Dis 2018;10:5576-83.