Original Article

Therapeutic rigid bronchoscopy at a tertiary care center in North India: Initial experience and systematic review of Indian literature

Karan Madan[1,2], Ritesh Agarwal[1], Ashutosh N. Aggarwal[1], Dheeraj Gupta[1]

[1]Department of Pulmonary Medicine, Postgraduate Institute of Medical Education and Research, Chandigarh, [2]Department of Pulmonary Medicine and Sleep Disorders, All India Institute of Medical Sciences, New Delhi, India

ABSTRACT

Background and Aim: Rigid bronchoscopy is often an indispensable procedure in the therapeutic management of a wide variety of tracheobronchial disorders. However, it is performed at only a few centers in adult patients in India. Herein, we report our initial 1-year experience with this procedure. **Materials and Methods:** A prospective observational study on the indications, outcomes, and safety of various rigid bronchoscopy procedures performed between November 2009 and October 2010. Improvement in dyspnea, cough, and the overall quality of life was recorded on a visual analog scale from 0 to 100 mm. A systematic review of PubMed was performed to identify studies reporting the use of rigid bronchoscopy from India. **Results:** Thirty-eight rigid bronchoscopies (50 procedures) were performed in 19 patients during the study period. The commonest indication was benign tracheal stenosis followed by central airway tumor, and the procedures performed were rigid bronchoplasty, tumor debulking, and stent placement. The median procedure duration was 45 (range, 30-65) min. There was significant improvement in quality of life associated with therapeutic rigid bronchoscopy. Minor procedural complications were encountered in 18 bronchoscopies, and there was no procedural mortality. The systematic review identified 15 studies, all on the role of rigid bronchoscopy in foreign body removal. **Conclusions:** Rigid bronchoscopy is a safe and effective modality for treatment of a variety of tracheobronchial disorders. There is a dire need of rigid bronchoscopy training at teaching hospitals in India.

KEY WORDS: Airway stents, bronchoscopy, central airway obstruction, interventional pulmonology, lung cancer, tracheal stenosis

Address for correspondence: Dr. Ritesh Agarwal, Department of Pulmonary Medicine, Postgraduate Institute of Medical Education and Research, Chandigarh - 160 012, India. E-mail: riteshpgi@gmail.com

INTRODUCTION

Rigid bronchoscopy is the transoral (or trans-tracheotomy) passage of rigid instruments for diagnostic or therapeutic purposes in the tracheobronchial tree. It was reported in the 19th century by Gustav Killian, and remained the only method for diagnostic and therapeutic procedures in the airways for a significant period.[1] The practice of rigid bronchoscopy greatly decreased following the invention of the flexible bronchoscope.[2] In fact in the last two decades, many pulmonologists have never been exposed to either the instruments or the rigid bronchoscopy procedure.[3] Despite three decades of providing training in the field of pulmonary medicine, we have only recently started therapeutic rigid bronchoscopy.

The rigid bronchoscope is superior to the flexible bronchoscope in many situations.[4] The rigid bronchoscope provides superior airway control, especially in cases of significant airway bleeding, and in removal of foreign bodies. For emergent central airway obstruction (CAO), rigid bronchoscopy is the airway stabilization procedure of choice.[5] In fact, the silicon stent can only be placed with the rigid bronchoscope. Advancements in the design of rigid bronchoscope, and availability of high definition optical systems have transformed the art of rigid bronchoscopic interventions. Moreover, the flexible

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bronchoscope can be passed through the barrel of the rigid bronchoscope and removes the restriction of visualization of the upper lobes and peripheral lesions.[6] Ideally, an interventional pulmonologist should be well versed with both rigid and flexible instruments while performing therapeutic bronchoscopic interventions.

We started therapeutic rigid bronchoscopy in 2009, and herein we report our initial 1-year experience with this procedure.

MATERIALS AND METHODS

This was a prospective observational study conducted at the Department of Pulmonary Medicine at Postgraduate Institute of Medical Education and Research, Chandigarh, between November 2009 and October 2010. The primary objective of the study was to observe the indications, outcomes, and safety of various rigid bronchoscopy procedures. The study population included all consecutive patients undergoing the rigid bronchoscopy procedure during the study period. The study protocol was approved by the Ethics Review Committee, PGIMER, Chandigarh, and a written informed consent was obtained from all patients (or next of the kin) prior to the procedure. All the patients had their history reviewed and underwent relevant physical examination prior to procedure. Preprocedure assessment included performance of complete blood count, coagulation profile, urea, and electrolytes.

Instruments for rigid bronchoscopy

Rigid tracheoscope and tracheobronchoscopes (Karl Storz, Germany) of lengths 33 cm and 43 cm, respectively, of varying internal diameters (3.5-14 mm) with proximally inserted prismatic light deflectors were used. Optical images were obtained using a Hopkins Straight Forward Telescope (with fiberoptic light system incorporated) of 2.9 mm diameter and 50 cm length. TONN stent applicator system (for stent with OD 14-18 mm and maximum 10 cm length) was employed for silicon stent deployment. Balloon dilatation was performed using controlled radial expansion (CRE) balloons (Boston Scientific, USA).

Anesthesia for rigid bronchoscopy

Rigid bronchoscopy was performed using total intravenous anesthesia. Patients were kept fasting for at least 6 h (2-3 h in emergency situations) prior to the procedure. All procedures were performed in the operating suite, where facilities of a trained anesthesia team were readily available. Induction was performed with propofol and fentanyl. Subsequently, suxamethonium was administered and rigid bronchoscopic intubation was carried out. Anesthesia was maintained with propofol infusion and muscle relaxation by suxamethonium or atracurium as intermittent boluses. At the end of the procedure, reversal of anesthesia was achieved with neostigmine and glycopyrrolate. Indications for continuing postprocedure ventilatory support were individualized according to patient's clinical condition, duration of procedure, and degree of laryngeal manipulation. In patients with critical narrowing of the airway lumen, only deep sedation was initially employed. Neuromuscular blockers were administered only once the airway was secured after negotiating the rigid bronchoscope across the obstructed airway.

Rigid bronchoscopic procedures

Rigid bronchoscopic intubation was performed according to the standard technique.[6] Once the trachea was intubated, the anesthetist ventilated the patient through the ventilating channel of the bronchoscope. The scope was further advanced into the trachea for visualization. Tracheal dilatation was performed by gentle corkscrewing motion of the barrel across the stenosed segments. Occasionally, CRE balloons were initially employed followed by passage of the rigid barrel. Luminal patency in central airway tumor was accomplished by mechanical debulking using the bevel of the rigid bronchoscope.[7] In all these procedures, care was taken to maintain the rigid barrel parallel to the tracheobronchial axis.

Outcomes

We recorded the time taken for the procedure, time to recovery from anesthesia, time to extubation, and procedural complications. Improvement in dyspnea, cough, and the overall quality of life was recorded on a visual analog scale (VAS) from 0 to 100 mm (0 = no improvement; 100 = complete relief). Routine radiological investigations and/or flexible bronchoscopy were performed to assess improvement in nature of lesion. Data are presented in a descriptive fashion using mean (standard deviation [SD]). The improvement in the pre- and post-procedure VAS was analyzed using the Wilcoxon signed-rank (matched pairs) test.

Systematic review

A systematic review of the PubMed database (1965 to April 2012) was performed using the following the search terms: (Rigid bronchoscopy OR rigid bronchoscope OR rigid tracheoscopy) AND (India OR Indian). We excluded case reports and series with <10 patients.

RESULTS

During the study period, 38 rigid bronchoscopies were performed on 19 patients. The median number of rigid bronchoscopies performed per patient was two (range, one to six). In 30 (79%) procedures, flexible bronchoscopy was performed for assessment prior to rigid bronchoscopy. The indications for rigid bronchoscopy are summarized in Table 1. The most common indication was benign tracheal stenosis followed by CAO due to tumors. Fifty procedures were performed during 38 interventions [Table 2]. Tracheal silicon and Montgomery T-tube stent placement was performed in five and two patients, respectively, with postintubation tracheal stenosis. In two patients with lung cancer and CAO, a silicone Y-stent was inserted [Figures 1-3]. The other procedures performed included suctioning of endobronchial mucus plugs (one

patient), stent repositioning (three patients), stent removal (three patients), suction, and tamponade along with endobronchial adrenaline instillation (one patient), right main bronchus balloon dilatation (one patient), and mitomycin C application over tracheal stenosis postrigid bronchoplasty (one patient). Rigid bronchoscope alone was used in 22 interventions (57.9%) and in 16 (42.1%) interventions, flexible bronchoscope was passed through the rigid barrel. Minor complications were encountered in 18 interventions [Table 3]; there was no procedural mortality.

The mean (SD) duration of the procedure was 66 (29) min. Twenty-five instances (65.8%) required assisted mechanical ventilation following the procedure. The median time to extubation was 8 h. The median time to discharge from the hospital following the procedure was 5 days (range, 1-22 days). Repeat interventions prior to discharge were carried out following the nine rigid bronchoscopies. Therapeutic bronchoscopy procedures were associated with a significant improvement in the quality of life scores as assessed by VAS [Table 4].

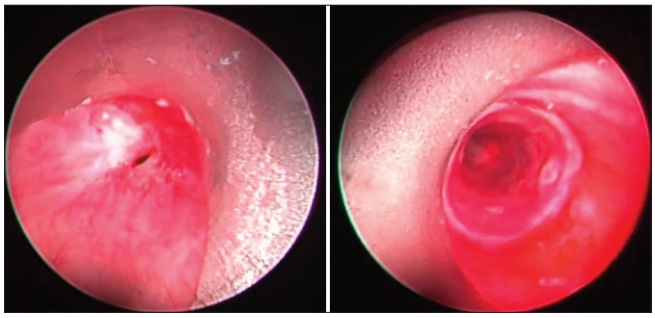

Figure 1: Pre- and postimages of a patient with upper tracheal stenosis following intubation. Rigid bronchoscopic dilatation was performed followed by straight tracheal silicon stent placement

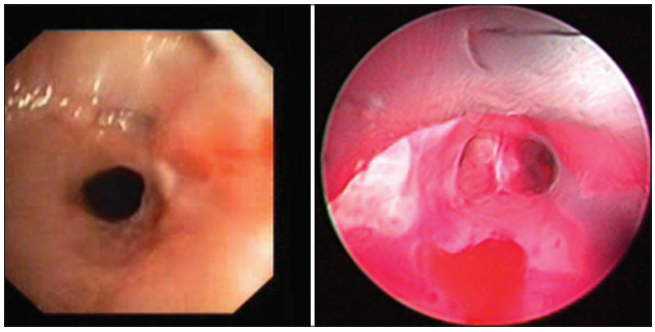

Figure 2: Pre- and postimages of a patient with tracheal stenosis 2 cm above the carina. Rigid bronchoscopic dilatation was performed followed by Y silicon stent placement

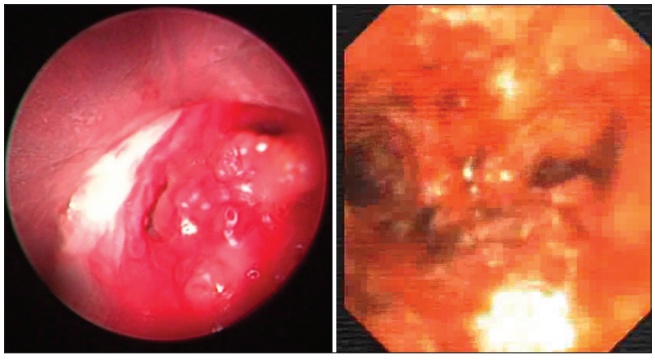

Figure 3: Pre- and postimages of a patient with bronchogenic carcinoma who presented with respiratory failure. Rigid bronchoscopy was performed and the tracheal tumor was gently cored with the barrel of the rigid bronchoscope

Systematic review

Our search yielded 39 references and 15 references met our criteria for inclusion [Table 5];[8-22] the remaining were mainly case-reports or small case series. All the reports are those involving foreign body removal using the rigid bronchoscope, some reports are those of combined rigid and flexible bronchoscopy.[8,9,22] The majority are those from the domain of the otorhinolaryngologist, in fact only one report involved the pulmonary physician.[9] The complication rate is variable and mortality has also been reported [Table 5]. There is no study reporting the use of rigid bronchoscopy for interventional pulmonology

Table 1: Indications for therapeutic rigid bronchoscopic procedures (*n*=38)

	No.
Tracheal stenosis (postintubation)	21
Central airway tumors	10
Foreign body removal	5
Mucus plugging	1
Massive hemoptysis	1

Table 2: Procedures (*n*=50) performed during therapeutic rigid bronchoscopy

	No.
Mechanical dilatation	18
Stent	9
Foreign body removal	5
Mechanical debulking	5
Others	13

Table 3: Number of complications encountered during rigid bronchoscopy

	No.
Minor bleeding	6
Upper lip injury	2
Laryngeal edema	2
Hypoxia	2
Tongue edema	2
Vocal cord trauma	1
Oropharyngeal injury	1
Arrhythmia	1
Tracheal mucosal tear	1

Table 4: Outcomes of quality of life (VAS in mm)

	Preprocedure	Postprocedure	*P* value
Dyspnoea	45±30	87±16	<0.01
Cough	46±30	79±17	<0.01
Overall QoL	49±26	82±17	<0.01

VAS: Visual analog scale

Table 5: Systematic review of studies from India reporting experience with rigid bronchoscopy

Author	Year	Number of patients	Patient characteristics	Technique	Procedural outcome	Complications
Das *et al*.[8]	2012	52 patients for foreign body (FB) removal over 2 years	Foreign body removal (Male [M]: 32, female [F]: 20). Maximum patients (14) were in the 2-3 years age group	RB and fiberoptic bronchoscopy (FOB)	Successful in most patients. Tracheotomy needed in some patients to aid FB removal. Removal of FB could not be done in two cases due to granulation tissue	One patient died due to anesthetic hazards. Most of the patients discharged after 48 hours except five who developed chest infection
Goyal *et al*.[9]	2012	266 patients with suspected tracheobronchial FB inhalation	Diagnosis of FB confirmed in 214. FB more common in males (59%) and age 1-2 years	FOB and RB	Successful removal of the FB in 207 patients. FOB (40% success) and RB (95% success)	Laryngeal edema, pneumothorax, and subcutaneous emphysema reported
Mukherjee *et al*.[10]	2011	94 patients with suspected tracheobronchial FB inhalation	70.2%, i.e., 66 were within 5 years of age and most were within 2-3 years of age	RB	FB was successfully retrieved in 78.7% of cases	None reported
Mahajan *et al*.[11]	2011	184 consecutive children with suspected tracheobronchial FB inhalation	Diagnosis of FB confirmed in 166. Highest incidence of FBA (126/166, 75.9%) was found in the age group between 1 and 5 years	RB	163 (98.2%) had successful retrieval in the first attempt and 3 (1.8%) required repeat attempt for removal. Surgical intervention was required in three of the cases. Two had failed bronchoscopic extraction	Two patients died. One had hypoxic brain damage due to delay in presentation. Other child had associated congenital heart disease who died due to cardiac failure and ventilator-related complications
Bhat *et al*.[12]	2010	To evaluate virtual bronchoscopy in comparison with rigid bronchoscopy, in 20 pediatric patients with tracheobronchial foreign bodies undetected by plain chest radiography	Computed tomography virtual bronchoscopy was performed in 20 patients in whom chest radiography appeared normal. Seven (35%) boys and 13 (65%) girls	RB	In 12 patients, foreign bodies detected by virtual bronchoscopy were confirmed by RB. In one case, a mucous plug was perceived as a foreign body on virtual bronchoscopy. In another case, a minute foreign body was missed on virtual bronchoscopy	None reported
Sinha *et al*.[13]	2010	32 patients with suspected foreign body inhalation over 2 years	Maximum number of cases was in the age group of 1-3 years (62.5%)	RB	RB performed in all patients. Only mucous plugs were found in seven patients (21%)	Tracheotomy done in four patients and foreign body was removed through tracheostoma in one patient
Singh *et al*.[14]	2009	Foreign body aspiration	342 children with foreign body obstruction	RB	Rigid bronchoscopy was successful in retrieving the foreign bodies in 338 (98.8%) cases	Four (1.2%) cases required additional tracheostomy, either to protect the airway during the procedure or to assist in removing the foreign body. No mortality or long-term complication because of the tracheostomies
Shubha *et al*.[15]	2009	Foreign body aspiration in infants	Retrospective review of 102 infants who underwent bronchoscopy for suspected FBA from 1997 to 2007. Mean age 10.5 months. Youngest being 2 months; M: F (72:30)	RB	No FB found in 5. Successful removal in the remaining patients	Two patients required postbronchoscopy mechanical ventilation and one, a repeat bronchoscopy. Other complications [pneumothorax (1), hypoxic seizures (1) and bronchospasm (2)] were successfully managed. No mortality in the series
Yadav *et al*.[16]	2007	Retrospective analysis of airway foreign bodies in 132 children	46% were younger than 3 years of age; M: F (80:52)	RB	Rigid bronchoscopy under general anesthesia was done in 129 cases. Foreign body was successfully removed in 93.2% of the cases. Peanuts were the commonest foreign body	Three patients presented with obstructed conditions and could not be resuscitated. No serious postoperative complication occurred, except for atelectasis in 11 cases (8.3%), all of whom responded well to physiotherapy

Contd...

Table 5: Contd...

Author	Year	Number of patients	Patient characteristics	Technique	Procedural outcome	Complications
Sinha *et al*.[17]	2007	30 patients with foreign body inhalation	Ages ranged from 6 months to 10 years; M: F (21:9)	RB	Out of the 30 bronchoscopies performed, exogenous foreign bodies were removed in 29 cases while one case had mucous plug causing endogenous bronchial obstruction. In 67% of cases, bronchoscopy with foreign body was done within 30 min	None. Uneventful postoperative period in all the cases
Soodan *et al*.[18]	2004	Thirty-six children for rigid bronchoscopy for removal of airway foreign bodies over a period of 2 years	Study done to compare spontaneous and controlled ventilation during anesthesia for removal of inhaled foreign bodies in children	RB	Foreign bodies were mostly organic in nature with history of aspiration varying from 1 day to 2 months. All patients in the spontaneous ventilation group converted to assisted ventilation because of either desaturation or inadequate depth of anesthesia	Complications seen were intraoperative bucking and coughing (statistically significant in the spontaneous group), ventricular arrhythmia, laryngospasm, convulsion and postoperative laryngeal edema, and severe cough
Batra *et al*.[19]	2004	44 children for tracheobronchial foreign body removal	Age 1-4 years. The primary aim of the study was to compare indication and recovery characteristics of sevoflurane and halothane; M: F (32:12)	RB	The authors concluded that halothane is as suitable as sevoflurane for children undergoing RB but sevoflurane has an advantage of quicker recovery. Exact details of RB procedure outcome not described as the study was focussed on the anesthesia perspective	Bradycardia and arrhythmias occurred in nine patients and desaturation (SpO_2<93%) occurred in nine patients. No procedure-related mortality reported
Shivakumar *et al*.[20]	2003	Review of 165 pediatric patients with suspected foreign body inhalation	96 boys (58.1%) and 69 girls (41.8%). Mean age 2.8 years	RB	Presence of foreign body confirmed and removed in 105 patients. Diagnosis ruled out at RB in 60 patients	One mortality due to hypoxia and cardiac arrest reported
Mathur *et al*.[21]	2003	To evaluate the merits and demerits of pediatric rigid bronchoscopy for foreign body removal with or without the use of Hopkins telescope	60 pediatric patients. 0-3 years of age (M: F 3:1). 30 underwent the telescopic and 30 underwent nontelescopic procedure	RB	Telescope provided better illumination, higher optical resolution, and magnification. Foreign body removal with telescope was completed with minimal complications (less foreign body drops and lesser grasping attempts) though the procedure took more time. Patients in the telescope group had shorter duration of hospital stay	The major complications encountered in the nontelescopic group were pneumothorax 2 (6.7%) and further impaction of the foreign body in 3 (10%). In the telescopic category, further impaction of the foreign body owing to the accidental pushing down of the object during the procedure was recorded in 3 (10%). Other minor complications were controllable bleeding and minor mucosal abrasions
Kapoor[22]	1982	Analysis of 240 bronchoscopic procedures	164 FB (all for diagnostic purpose) and 76 RB (2 for therapeutic and rest diagnostic) procedures	RB and FOB	Positive diagnostic results 85% with FB versus 73% with RB. FB provided better visualization as compared to RB. Four failed RB procedures (in 3 scope could not be negotiated beyond the glottis and in one scope could not be negotiated beyond the trachea)	One death reported with FB. None with RB

RB: Rigid bronchoscopy, FOB: Fiberoptic bronchoscopy, FBA: Foreign body aspiration

procedures such as central airway tumors, tracheal stenosis, and stent placement.

DISCUSSION

This study was conducted in the setting of one of the largest tertiary care teaching institutes of North India. During the study duration, the majority of the therapeutic bronchoscopy procedures were performed using the rigid bronchoscope. In 80% cases, the therapeutic rigid bronchoscopic intervention was performed for the management of CAO. In India, the most commonly reported use of rigid bronchoscopy is for foreign body removal. In fact, our systematic review did not identify any study reporting the use of rigid bronchoscopy for interventional pulmonology procedures such as tumor debulking, stent placement, and others. At the time of initiation of the study, we had anticipated that most procedures would be performed for palliation in malignant tracheobronchial obstruction. In contrast to our expectation, the majority of these interventions were in benign conditions (77.2%) with a therapeutic rather than palliative intent.

Bronchoplasty in cases of benign tracheal stenosis was performed with the barrel of the rigid scope by sequential dilatation and occasionally using the CRE balloon. Dilatation was followed by silicon stent placement in seven cases of tracheal stenosis. There was dramatic symptom relief in all these cases as has been well highlighted in the literature.[6,23-25] All our patients with tracheal stenosis had circumferential strictures that have been shown to be associated with poorer outcomes. They also require more aggressive intervention than the eccentric strictures.[26] This was apparent by the repeated requirement of rigid bronchoscopic dilatations and repeated restenosis. Mitomycin C application was applied after rigid bronchoscopic dilatation of tracheal stenosis in one patient, but its use in benign tracheal stenosis is a controversial topic.[27] The definitive treatment of benign tracheal stenosis remains tracheal reconstruction surgery.[28] However, surgery could not be performed in our patients both because of lack of surgical expertise and unwillingness of the patients. Five rigid bronchoscopy procedures were performed for foreign body removal of which four were successful.

One patient had a long history of foreign body inhalation with excessive granulation tissue covering the foreign body. In one patient, rigid bronchoscopy was used successfully for the management of massive hemoptysis, where it is the method of choice due to its better suction ability.[29]

Previously, external beam radiation was considered the treatment of choice for patients with CAO. If interventional pulmonology services are available, endoscopic interventions should be strongly considered as the first line of management of CAO as the results of external beam radiation are delayed and often unpredictable. Rigid bronchoscopy allows immediate results and has a favorable safety profile.[30] Although tumor excision has been performed using the flexible bronchoscope,[31] it can be most rapidly and safely accomplished through the rigid bronchoscope.[32] Radiation therapy can then consolidate the effect of endoscopic therapy, usually in patients whose performance status has been improved by a first-line bronchoscopic intervention.

Performance of therapeutic rigid bronchoscopy requires teamwork especially understanding between the interventionist and the anesthetist as they share the airway. At least three team members are required for quick and easy performance of the procedure. We had a primary assistant who stood beside the operator and was involved in cleaning the telescope tip in between the insertions and management of the equipment assembly and optics, suctioning and manipulation of the forceps, and the CRE balloon as and when required. The respiratory technician was present behind the operating team and was involved in the management and handing over the instruments to the operating team.

In conclusion, this study reports our initial experience with rigid bronchoscopy and highlights the advantage of this procedure. Currently, the flexible bronchoscope is being employed for the majority of the diagnostic and many therapeutic bronchoscopic procedures. This has led to decline in rigid bronchoscopy training, even at most teaching institutes. However, it is essential that the pulmonologists are familiar with rigid bronchoscopy as the rigid bronchoscope remains the "gold" standard technique for therapeutic airway procedures.

REFERENCES

1. Zollner F. Gustav Killian, father of bronchoscopy. Arch Otolaryngol 1965;82:656-9.
2. Ikeda S. Flexible bronchofiberscope. Ann Otol Rhinol Laryngol 1970; 79:916-23.
3. Prakash UB, Offord KP, Stubbs SE. Bronchoscopy in North America: The ACCP survey. Chest 1991;100:1668-75.
4. Ayers ML, Beamis JF, Jr. Rigid bronchoscopy in the twenty-first century. Clin Chest Med 2001;22:355-64.
5. Ernst A, Feller-Kopman D, Becker HD, Mehta AC. Central airway obstruction. Am J Respir Crit Care Med 2004;169:1278-97.
6. Agarwal R, Khan A, Aggarwal AN, Singh N, Bhagat H, Kumar B, *et al*. Initial experience of endobronchial silicon stents from a tertiary care centre in North India. Indian J Chest Dis Allied Sci 2011;53:93-8.
7. Vishwanath G, Madan K, Bal A, Aggarwal AN, Gupta D, Agarwal R. Rigid bronchoscopy and mechanical debulking in the management of central airway tumors: An Indian experience. J Bronchology Interv Pulmonol 2013;20:127-33.
8. Das SK, Singh B, Sengupta A. Foreign bodies in bronchus-2 years experience at IPGME and R, Kolkata. J Indian Med Assoc 2012; 110:397-8.
9. Goyal R, Nayar S, Gogia P, Garg M. Extraction of tracheobronchial foreign bodies in children and adults with rigid and flexible bronchoscopy. J Bronchology Interv Pulmonol 2012;19:35-43.
10. Mukherjee M, Paul R. Foreign body aspiration: Demographic trends and foreign bodies posing a risk. Indian J Otolaryngol Head Neck Surg 2011;63:313-6.
11. Mahajan JK, Rathod KK, Bawa M, Rao KL. Tracheobronchial Foreign Body Aspirations: Lessons Learned From a 10-year Audit. J Bronchology Interv Pulmonol 2011;18:223-8.
12. Bhat KV, Hegde JS, Nagalotimath US, Patil GC. Evaluation of computed

tomography virtual bronchoscopy in paediatric tracheobronchial foreign body aspiration. J Laryngol Otol 2010;124:875-9.
13. Sinha V, Chhaya V, Barot DS, Mehta K, Patel P, Patil S, *et al*. Foreign body in tracheobronchial tree. Indian J Otolaryngol Head Neck Surg 2010;62:168-70.
14. Singh JK, Vasudevan V, Bharadwaj N, Narasimhan KL. Role of tracheostomy in the management of foreign body airway obstruction in children. Singapore Med J 2009;50:871-4.
15. Shubha AM, Das K. Tracheobronchial foreign bodies in infants. Int J Pediatr Otorhinolaryngol 2009;73:1385-9.
16. Yadav SP, Singh J, Aggarwal N, Goel A. Airway foreign bodies in children: Experience of 132 cases. Singapore Med J 2007;48:850-3.
17. Sinha V, Memon R, Gupta D, Prajapati B, Bhat V, More Y. Foreign body in tracheobronchial tree. Indian J Otolaryngol Head Neck Surg 2007; 59:211-4.
18. Soodan A, Pawar D, Subramanium R. Anesthesia for removal of inhaled foreign bodies in children. Paediatr Anaesth 2004;14:947-52.
19. Batra YK, Mahajan R, Bangalia SK, Chari P, Rao KL. A comparison of halothane and sevoflurane for bronchoscopic removal of foreign bodies in children. Ann Card Anaesth 2004;7:137-43.
20. Shivakumar AM, Naik AS, Prashanth KB, Shetty KD, Praveen DS. Tracheobronchial foreign bodies. Indian J Pediatr 2003;70:793-7.
21. Mathur NN, Pradhan T. Rigid pediatric bronchoscopy for bronchial foreign bodies with and without Hopkins telescope. Indian Pediatr 2003;40:761-5.
22. Kapoor SC. Comparative study of Fiberbronchoscopy and Rigid Bronchoscopy. Lung India 1982;1:25-8.
23. Bolliger CT, Probst R, Tschopp K, Soler M, Perruchoud AP. Silicone stents in the management of inoperable tracheobronchial stenoses. Indications and limitations. Chest 1993;104:1653-9.
24. Dumon JF. A dedicated tracheobronchial stent. Chest 1990;97:328-32.
25. Vergnon JM, Costes F, Bayon MC, Emonot A. Efficacy of tracheal and bronchial stent placement on respiratory functional tests. Chest 1995;107:741-6.
26. Simpson GT, Strong MS, Healy GB, Shapshay SM, Vaughan CW. Predictive factors of success or failure in the endoscopic management of laryngeal and tracheal stenosis. Ann Otol Rhinol Laryngol 1982;91:384-8.
27. Madan K, Agarwal R, Aggarwal AN, Gupta D. Utility of rigid bronchoscopic dilatation and mitomycin C application in the management of postintubation tracheal stenosis: Case series and systematic review of literature. J Bronchology Interv Pulmonol 2012;19:304-10.
28. Maassen W, Greschuchna D, Vogt-Moykopf I, Toomes H, Lullig H. Tracheal resection: State of the art. Thorac Cardiovasc Surg 1985;33:2-7.
29. Helmers RA, Sanderson DR. Rigid bronchoscopy. The forgotten art. Clin Chest Med 1995;16:393-9.
30. Wahidi MM, Herth FJ, Ernst A. State of the art: Interventional pulmonology. Chest 2007;131:261-74.
31. Madan K, Agarwal R, Bal A, Gupta D. Bronchoscopic management of a rare benign endobronchial tumor. Rev Port Pneumol 2012;18:251-4.
32. Gerasin VA, Shafirovsky BB. Endobronchial electrosurgery. Chest 1988; 93:270-4.

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