Original Article

Bronchoscopic device closure of postoperative bronchopleural fistulae: Novel devices and innovative techniques

Vikas Marwah[1], CDS Katoch[1], Kunal Kumar[1], Kamal Pathak[2], Saikat Bhattacharjee[3], Prashant Jindamwar[4]

[1]Department of Pulmonary, Critical Care and Sleep Medicine, Military Hospital (CTC), Pune, Maharashtra, India, [2]Department of Interventional Radiology, Excelcare Hospitals, Guwahati, Assam, India, [3]Department of Radiology, Military Hospital (CTC), Pune, Maharashtra, India, [4]Department of Microbiology, Military Hospital (CTC), Pune, Maharashtra, India

ABSTRACT

Background: Bronchoscopic device closure plays a significant role in the nonsurgical management of bronchopleural fistulae (BPF). Herein, we describe our 10-year experience in the management of postoperative BPF using various device closure modalities. This is the largest series of bronchoscopic device closure of BPF being reported from India. **Materials and Methods:** This was a retrospective analysis of data of patients who underwent bronchoscopic device closure with various techniques for the management of postoperative BPF. In total, 11 patients (six males and five females) with a mean age (±standard deviation) of 42.72 ± 14.40 years with BPFs were treated with various bronchoscopic interventions for BPF closure. We used various devices such as endobronchial coils, occluder devices, and covered tracheobronchial self-expandable stents for BPF closure depending on the size of air leaks. We describe the various devices used, technique, and outcome of bronchoscopic management of BPF. **Results:** All our patients had developed BPFs postoperatively. Pulmonary tuberculosis was the most common etiology seen in nine of our patients. All the devices were placed using a fiberoptic bronchoscope, and all patients were followed up for a minimum duration of 6 months. We successfully localized and closed BPFs in nine (81.81%) of our patients. **Conclusions:** Bronchoscopic device closure can be a successful strategy to manage postoperative BPF with minimal complications.

KEY WORDS: Bronchoscopic device closure, postoperative bronchopleural fistulae, therapeutic bronchoscopy

Address for correspondence: Dr. Vikas Marwah, Department of Pulmonary, Critical Care and Sleep Medicine, Military Hospital (CTC), Pune - 411 040, Maharashtra, India. E-mail: docvikasmarwah@gmail.com

Submitted: 22-Apr-2019 **Revised:** 12-Oct-2019 **Accepted:** 12-Nov-2019 **Published:** 27-Feb-2020

INTRODUCTION

Bronchopleural fistulae (BPFs) are a direct communication between the tracheobronchial tree and the pleural space. In a recent study, the incidence of BPF was 0.5% for lobectomy, 2.2% for bilobectomy, and 3% for pneumonectomy.[1] Other causes include pulmonary infections, spontaneous pneumothorax, tuberculosis (TB), chest trauma, radiotherapy for lung cancer, and as a complication of mechanical ventilation.[1-5] BPFs are associated with a high morbidity.[6-8] Delayed closure of the BPF may lead to an increased risk of complications such as empyema and prolonged hospital stay.[4,9]

Access this article online

Quick Response Code:

Website: www.lungindia.com

DOI: 10.4103/lungindia.lungindia_179_19

How to cite this article: Marwah V, Katoch CDS, Kumar K, Pathak K, Bhattacharjee S, Jindamwar P. Bronchoscopic device closure of postoperative bronchopleural fistulae: Novel devices and innovative techniques. Lung India 2020;37:107-13.

Bronchoscopy allows not only to localize BPFs but also plays a significant role in the nonsurgical management of BPFs.[2,10] Bronchoscopic management of air leaks involves the use of various agents such as glue, gel foam, metallic coils, endobronchial valves, sealants, stents, sclerosants, and various closure devices.[9-13]

Here, we describe a case series of 11 patients in whom various methods were used to manage BPFs.

MATERIALS AND METHODS

We have done a retrospective analysis of device closure of BPFs between 2008 and 2018. In total, 11 patients (six males and five females) with BPFs were treated with various bronchoscopic interventions for BPF closure. The mean age of our study group (±standard deviation) was 42.72 ± 14.40 years. Demography of the patients and etiology of BPFs described in our previous case reports and the present study are presented in Table 1. Our management algorithm is summarized in Figure 1.

We used endobronchial coils with sealants for small air leaks <4 mm. The endobronchial coils used were vascular embolization spring occluding coils. The material used as a sealant was BioGlue which is a two-component adhesive composed of purified bovine serum albumin and glutaraldehyde. BioGlue solutions were dispensed by a controlled delivery system. Once dispensed, BioGlue begins to set up within 20–30 s and reaches its bonding strength within 2 min.[14]

Ductal occluder devices are used by cardiologists for the closure of patent ductus arteriosus (PDA). These devices are made up of nitinol mesh and are used for 4–8 mm air leaks. We used ductal occluder devices of two different manufacturers (a) nitinol ductal occluder device (Lifetech™; Shenzhen, PR China) of size 10 mm (proximal waist), 8 mm (distal waist), 7 mm (length), and retention skirt of 2 mm on either side and (b) Amplatzer ductal occluder device (AGA Medical; Golden Valley, Minnesota) with a central waist of 6 mm and length 6 mm.

Atrial septal occluder device was used for air leaks 8 mm. This is a self-expanding double disc joined by a mesh tube. This device is used by cardiologists for the closure of atrial septal defects. This device is made up of nitinol wire mesh with polyester patches sewn within the discs and central mesh tube. The waist size varies between 4 mm and 40 mm, and it helps to self-center the device during deployment.

Covered tracheobronchial self-expandable metallic stents were used for air leaks >8 mm. Covered tracheobronchial self-expandable metallic stent (Mitra Industries, Faridabad, India) is made up of a nitinol mesh with a thin inner silicone membrane covering. Larger heads on both ends prevent the stent from migration. These stents are used in various sizes depending on the size of the bronchopleural fistula. The right main bronchus is approximately 2 cm in length compared to the left main bronchus, which has an average length of 5 cm.[15] We restricted the use of stents to the left lung only, owing to the peculiar anatomy of the right main bronchus and risk of unintentional exclusion of the right middle lobe bronchus from the functional tracheobronchial tree while attempting closure of air leaks located in the right upper lobe.

Techniques

All the patients underwent computed tomography (CT) of the chest followed by bronchoscopy. We did a chest CT to determine the anatomical location of air leak (central vs. peripheral) and size of air leak and estimate the measurements of the tracheobronchial tree for each patient. We followed chest CT with fiberoptic bronchoscopy (Olympus BF-1T150, [Olympus Corporation, Japan] insertion tube outer diameter 6.0 mm, instrument channel inner diameter 2.8 mm) for BPF visualization. BPF was confirmed by direct visualization of fistula in

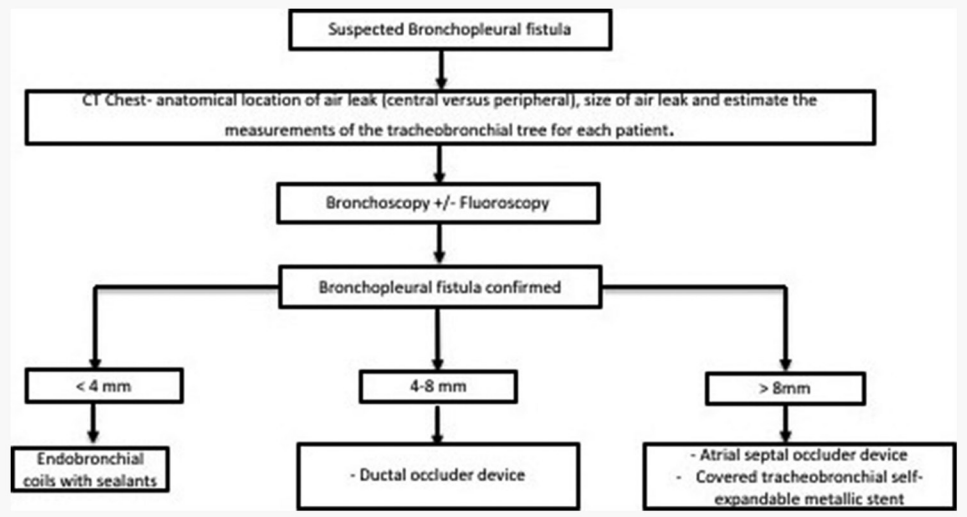

Figure 1: Bronchoscopic management algorithm for patients as per bronchopleural fistulae size

some cases, whereas in others, we resorted to selective instillation of methylene blue dye with its subsequent appearance in the chest tube. We used fluoroscopic guidance along with bronchoscopy for BPF localization in two patients only (patient 1 and 11). In these two patients, BPF tract was delineated by contrast injection under fluoroscopic guidance. We had to resort to fluoroscopy guidance in these two patients as we were facing difficulty in precise delineation of the fistulous tract for therapeutic intervention with bronchoscopy alone.

The choice of the technique of BPF closure was determined by the location and size of the air leak, history of a failed surgical attempt of BPF closure, the general condition of the patient, and willingness of the patient to undergo the procedure. Patients who were unwilling for surgical closure of BPF or those with very high surgical risk were also considered for bronchoscopic management of BPF.

All patients were sensitized about the risks involved, and written informed consent was obtained. All patients were counseled about the off-label use of various devices used for BPF closure. All the patients were kept nil per orally for a minimum duration of 4 h. The procedure was carried out in a bronchoscopy suite under local anesthesia, and conscious sedation was used during the procedure. We did not require general anesthesia during the procedure. Moderate sedation was given to all the patients, in whom we deployed stents as cough would have hampered accurate stent deployment. Ten percent lignocaine was sprayed at the vocal cords for local anesthesia. All patients were given supplemental oxygen via nasal prongs throughout the procedure and were placed on continuous cardiac monitoring. The fiberoptic bronchoscope was introduced through oral or nasal route. During the procedure, all patients were given 1–2 ml aliquots of 1% lignocaine using "spray as you go" technique. In all the cases, we oversized the device by 20% of the bronchial diameter to allow better apposition and prevent air leak between the device and the airway wall. All the patients were followed up for a minimum duration of 6 months after the therapeutic bronchoscopic intervention.

Endobronchial coils

Endobronchial coils followed by Bioglue was used in five patients having air leaks <4 mm (patients 7, 8, 9, 10, and 11). The fiberoptic bronchoscope was inserted via the nasal route under local anesthesia. The catheter for guiding the embolization coil was introduced through the instrument channel of the bronchoscope. The first metallic coil was then anchored at the fistula. After anchoring all the coils at the fistula, Bioglue was sprayed through the catheter to obliterate the small gaps between the coils [Figure 2a]. If patients had a recurrence of symptoms, re-instillation of Bioglue was attempted.

Occluder devices

We used the ductal occluder device in two of our patients (patients 1 and 2).[16] We used an atrial septal occluder device in only one patient (patient 3).[17] BPF was successfully localized with the help of chest CT and bronchoscopy. We used fluoroscopy for tract delineation in patient 1, whereas for patients 2 and 3, it was not deemed necessary as we were able to successfully delineate the fistulous tract using chest CT and bronchoscopy only. An extra stiff 0.035" wire (Cook medical, Bloomington, USA) was passed through the working channel of the bronchoscope to gain access into the bronchopleural fistula opening and onward to the pleural space and then the sinus track. The bronchoscope was withdrawn

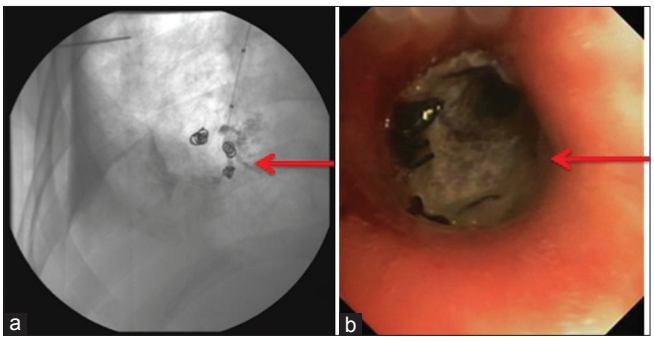

Figure 2: (a) Fluoroscopic image showing successful placement of endobronchial coil in patient 11. (b) Bronchoscopic image of covered bronchial self-expandable metallic stent used in patient 5

Table 1: Characteristic of patients and fistulas

Characteristic		Patients, *n*=11, *n* (%)	Patient serial number as per table 2
Sex	Male	6 (54.54%)	
	Female	5 (45.45%)	
Etiology	Multidrug resistant pulmonary tuberculosis with hemoptysis	1 (9.09%)	Patient 1
	Pulmonary tuberculosis (relapse) with hemoptysis	1 (9.09%)	Patient 2
	Post tubercular bronchiectasis with hemoptysis	2 (18.18%)	Patient 3 and 7
	Post tubercular sequelae with aspergilloma and hemoptysis	3 (27.27%)	Patient 4,5 and 10
	Post tubercular sequelae (persistent cavity) and hemoptysis	1 (9.09%)	Patient 6
	Tuberculous empyema (right)	1 (9.09%)	Patient 11
	Cystic pulmonary hydatidosis	2 (18.18%)	Patient 8 and 9
Type of operative intervention	Right upper lobectomy	3 (27.27%)	Patient 1,2 and 10
	Right lower lobectomy	1 (9.09%)	Patient 7
	Left upper lobectomy	3 (27.27%)	Patient 4,5 and 6
	Left lower lobectomy	2 (18.18%)	Patient 8 and 9
	Pnemonectomy (right)	1 (9.09%)	Patient 3
	Decortication (right)	1 (9.09%)	Patient 11

from the wire to be repositioned by the side of the wire. Keeping bronchoscope parallel to wire gave us good visualization and better bronchoscopic control during the procedure. The wire was torqued to guide it along the sinus tract till the skin wound and was made to exit by "pull-and-push" technique. A device delivery sheath

Table 2: Demographic and treatment profile of patients

Patient id	Age in years/sex (M/F)	Location of BPF	Size of BPF	Previous treatment/ surgery	Primary disease and comorbidities	Bronchoscopic intervention	Follow up duration (months)	Outcome
1	25/F	Right upper lobe	8 mm	Right upper lobectomy and excision of cavity in right lower lobe	Multidrug resistant tuberculosis with persistent large cavity in superior segment of right lower lobe and bronchiectasis in right upper lobe and hemoptysis	Ductal occluder device (Nitinol PDA device, LifetechTM; Shenzhen, PR China) of size 10 mm (proximal waist), 8 mm (distal waist), 7 mm (length), and retention skirt of 2 mm on either side	24	Successful bronchoscopic closure of BPF
2	24/F	Right upper lobe	5 mm	Right upper lobectomy	Pulmonary tuberculosis (relapse) with bronchiectasis in right upper lobe and hemoptysis	Ductal occluder device (Amplatzer ductal occluder device, AGA Medical; Golden Valley, Minnesota) with central waist of 6mm and length 6mm	24	Successful bronchoscopic closure of BPF
3	65/M	Right bronchial stump	11.4 mm	Right upper lobectomy with failed attempted surgical closure of BPF followed by creation of modified eloesser flap for drainage of empyema. Pneumonectomy in view of massive hemorrhage after lobectomy	Post tubercular bronchiectasis with hemoptysis	14mm atrial septal occluder device (LifetechTM; Shenzhen, PR China)	24	Successful bronchoscopic closure of BPF
4	51/M	Left upper lobe	11.5 mm	Left upper lobectomy, failed surgical repair with bovine pericardial patch, decortication left	Post tubercular sequelae with Aspergilloma and hemoptysis	14 mm x 40 mm covered Tracheobronchial self-expandable metallic stent (Mitra industries, Faridabad, India)	24	Successful bronchoscopic closure of BPF
5	66/M	Left upper lobe	9.8 mm	Thoracoplasty, left upper lobectomy, failed surgical closure of BPF and creation of modified eloesser flap for drainage of empyema	Post tubercular sequelae with Aspergilloma and hemoptysis	12 mm x 40 mm covered Tracheobronchial self-expandable metallic stent (Mitra industries, Faridabad, India)	06	Successful bronchoscopic closure of BPF
6	26/M	Left upper lobe	11.4 mm	Left upper lobectomy, failed surgical repair of BPF along with omental flap transposition	Post tubercular sequelae (persistent cavity) with hemoptysis	14 mm x 40 mm covered Tracheobronchial self-expandable metallic stent (Mitra industries, Faridabad, India)	18	Successful bronchoscopic closure of BPF
7	42/F	Right lower lobe	3.8 mm	Right lower lobectomy	Post tubercular bronchiectasis with hemoptysis	Endobronchial coils followed by bioglue	24	Recurrence of symptoms and failed closure. Later stump closed surgically
8	33/M	Left lower lobe	2 mm	Left lower lobectomy	Cystic pulmonary hydatidosis	Endobronchial coils followed by bioglue	12	Glue reinstilled after one year followed by successful bronchoscopic closure of BPF
9	38/M	Left lower lobe	3.1 mm	Left lower lobectomy	Cystic pulmonary hydatidosis	Endobronchial coils followed by bioglue	15	Glue reinstilled after one year followed by successful bronchoscopic closure of BPF
10	52/F	Right upper lobe	3.6 mm	Right upper lobectomy	Post tubercular sequelae with Aspergilloma and hemoptysis	Endobronchial coils followed by bioglue	24	Recurrence of symptoms and failed closure. Later stump closed surgically
11	48/F	Right lower lobe	2 mm	Decortication and closure of pleurocutaneous fistula. Re-exploration and failed attempted closure of BPF with Pectoralis major myoplasty	Tuberculous empyema (right) not responding to conservative management	Endobronchial coils followed by bioglue	24	Successful bronchoscopic closure of BPF

was passed transcutaneously over the wire, and its tip was positioned in the fistula site under bronchoscopic control. After removing the wire, ductal occluder device was selected and loaded into the delivery sheath. The device was pushed up to the proximal level of fistula and released under bronchoscopic control to occlude the fistula.[16] We followed similar procedure for atrial septal occluder device. The device was placed inside the sheath and deployed transcutaneously over the fistula. The outer (distal) portion of the disc was deployed successfully in the pleural cavity.

Covered tracheobronchial self-expandable metallic stent

We used covered tracheobronchial self-expandable metallic stent in three of our patients (patients 4, 5, and 6). We passed the fiberoptic bronchoscope (outer diameter 6.2 mm) via nasal route through the vocal cord. After the localization of the BPF site, a super-stiff guidewire (0.038") was passed through the working channel of the bronchoscope up to the left upper bronchial stump. After localizing the BPF with 0.038" super-stiff guidewire under the bronchoscopic guidance, we passed a 60 cm (length) × 6 mm (width) delivery device over the guidewire. We preferred the peroral route for stent deployment. The bronchoscope was positioned parallel to the delivery device, which enabled continuous visualization of the procedure and achieved better procedure control during stent deployment. Deployment of the stent was achieved by the "pulling back" technique. Pulling back the outer sheath of the delivery device deployed the stent at the desired location. Forceps were used through the working channel of the bronchoscope to correctly position the stent ensuring that the convexity of the stent was centered over the bronchus orifice planned for closure. Under the bronchoscopic guidance, the stent was placed in a manner such that the proximal end of the prosthesis was 1 cm proximal to the opening of left upper lobectomy (LUL) bronchus and bridging the left main bronchus with left lower lobe bronchus. The technique for stent deployment was the same in all the three patients (patients 4, 5, and 6). All patients were advised regarding care of stent and discharged after an observation period of 48 h. A bronchial check was performed at 24 h, 7 days, and 3 months.

RESULTS

The demographic and treatment profile for each patient is given in Table 2. Pulmonary TB and its sequelae were the most common etiology seen in nine of our patients. Out of the nine patients with tubercular etiology, eight (patients 1, 2, 3, 4, 5, 6, 7, and 10) had undergone lobectomy for the management of hemoptysis unresponsive to conservative management. One of the cases needed pneumonectomy (patient 3) in the immediate postoperative period after lobectomy, as a life-saving measure due to massive hemorrhage. Patient 3 was considered for atrial septal occluder device for BPF management after air leak persisted post pneumonectomy. Three patients in our study group had developed aspergilloma within the residual tuberculous cavity (patients 4, 5, and 10). Patient 5 developed BPF and pleurocutaneous fistula postoperatively after LUL and thoracoplasty. Patients 3 and 5 had to undergo creation of modified Eloesser flap for adequate drainage of the pleural cavity before they were taken up for bronchoscopic intervention for BPF. Patient 4 had undergone a failed surgical attempt of BPF closure with bovine pericardial patch. Patient 6 had undergone attempted surgical repair of BPF along with omental flap transposition to promote healing, but after failure of these measures, he had also ended up with persistent BPF and pleurocutaneous fistula. Patient 11 had undergone decortication for persistent tuberculous empyema with pleurocutaneous fistula and developed BPF postoperatively. Two patients developed BPFs post left lower lobe lobectomy for cystic pulmonary hydatidosis and the leak was from the bronchial stump (patient 8 and 9). Overall, seven patients in our study had pleurocutaneous fistula along with BPF (patients 1, 2, 3, 4, 5, 6, and 11).

We were successful in localizing and closing BPFs in all the patients, in whom we used PDA or atrial septal occluder devices (patients 1, 2, and 3).

We successfully managed BPFs in three of our patients with the bronchoscopic placement of the covered tracheobronchial self-expandable metallic stent (patients 4, 5, and 6). Endobronchial coils were successful in three patients only (patients 8, 9, and 11), and the other two (patients 7 and 10) were twice instilled glue after the placement of coils; however, they continued to be symptomatic and later underwent surgical stump closure.[14] All patients with BPF and associated pleurocutaneous fistula underwent successful bronchoscopic closure of BPF by various devices (patients 1, 2, 3, 4, 5, 6, and 11). Closure of BPF in these patients reduced the drainage from pleuro-cutaneous fistula, aiding its closure. We were able to successfully localize and close BPFs in nine (81.81%) of our patients.

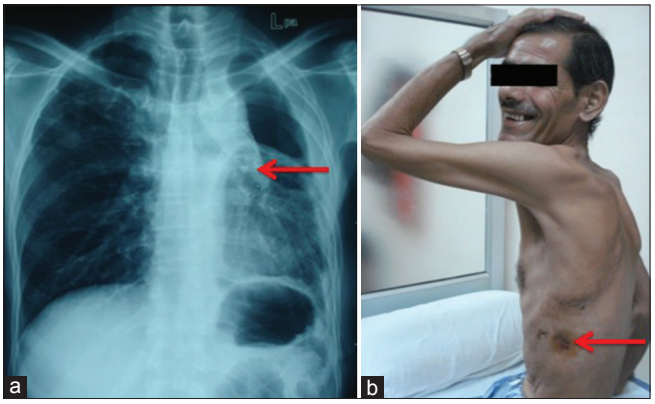

Figure 3: (a) Chest radiograph 1 week after covered Self-expandable metallic stent (SEMS) placement in patient 4. (b) Healed pleurocutaneous fistula in patient 4 after bronchopleural fistulae closure

DISCUSSION

Various methods have been described for the closure of BPFs with varying success rates.[8,10,14,18-21] In our study, we have used a fiberoptic bronchoscope to place various devices under direct visualization to secure BPFs. We used fluoroscopic assistance in two cases only (patients 1 and 11).

Cardiologists have traditionally used ductal occluder device and atrial septal occluder device to manage congenital heart defects.[16,17] Scordamaglio *et al*. described a case series of nine postpneumonectomy patients in whom atrial septal occluder devices were used for stump closure.[22] Fruchter *et al*. have published a series of ten cases that were managed by Amplatzer atrial septal occluder devices.[18] In our series, we successfully placed a 14-mm atrial septal occluder device in one patient (patient 3) and ductal occluder device transcutaneously over the fistula under bronchoscopic control in two of our patients for the management of BPF and discharging pleurocutaneous fistula (patients 1 and 2).[16,17] While Scordamaglio *et al*. used pulmonary inhalation scintigraphy to determine air leak at baseline and Fruchter *et al*. relied on periprocedural fluoroscopy along with bronchoscope for fistula localization, we just did a baseline CT of the chest for fistula delineation while planning the placement of an atrial septal occluder device. In our series, we have successfully placed various occluder devices transcutaneously over the fistula under fiberoptic bronchoscopic control and conscious sedation in three of our patients for the management of BPF and discharging pleurocutaneous fistula.

Stents are commonly used to minimize extrinsic compression of the airway or to maintain patency of airway after removal of the intrinsic cause of obstruction like an endobronchial tumor. They are also used to prevent dehiscence of the bronchial stump after pneumonectomy.[23,24] Various authors have described the use of Dumon stent for the closure of postsurgical stump leak.[25,26] Takahashi *et al*. described the use of covered metallic stent for palliative creation of an airway to block an air leak due to BPF.[27] In a case of an LUL with air leak, they used metallic stent under fluoroscopic guidance to create a one-way airway to the right lung and blocking the left lung completely.[27] de Lima *et al*. have described a case report in which they successfully used a modified Y stent in a patient post left pneumonectomy.[28] Bellato *et al*. have described the use of covered metallic bronchial stent using rigid bronchoscopy in a case of postoperative BPF with limited success.[29] Andreetti *et al*. and Dutau *et al*. have described case series of six and seven patients, respectively, in whom they used metallic stents to exclude the leaky bronchial stump from the main tracheobronchial tree. All these patients had undergone pneumonectomy for various underlying disorders and had developed stump leak postsurgery.[30,31] In our series, we used bronchial stents in three patients (patients 4, 5, and 6). All the three patients had an active discharging sinus as a result of pleurocutaneous fistula, which was debilitating. In patient 5, we used a 12 mm × 40 mm covered self-expanding metallic bronchial stent to exclude the LUL bronchus from the left tracheobronchial tree [Figure 2b]. We used a 14 mm × 40 mm covered self-expanding metallic bronchial stent to bridge the left main bronchus with the left lower lobe bronchus excluding the LUL bronchus [Figure 3a and b] in patients 4 and 6. In the case series by Andreetti *et al*. and Dutau *et al*., covered bronchial metallic stents were used in postpneumonectomy patients only and stent was placed into position using a rigid bronchoscope.[30,31] In the case report by Takahashi *et al*., for a left lung BPF, they placed a covered self-expanding metallic stent in the right main bronchus, resulting in a compromised function of the entire left lung.[27] Dutau *et al*. and Takahashi *et al*. resorted to general anesthesia during the procedure, whereas Andreetti *et al*. used deep sedation.[27,30,31] In all the three cases (patients 3, 4, and 5), we placed covered bronchial self-expanding metallic stents under fiberoptic bronchoscope guidance and conscious sedation without any fluoroscopic assistance into the left lung to successfully close air leak as well as to maintain the patency of the left lower lobe bronchus. Unlike Takahashi *et al*., in our cases, pulmonary function was not compromised. In our literature search, we could not find any case report of the similar use of a bronchial stent and to our knowledge, this is the largest series that describes the use of covered tracheobronchial self-expanding metallic stents for successful BPF closure using fiberoptic bronchoscope without any fluoroscopic guidance.

In our series, we have been successful with these unconventional approaches for the closure of BPF in nine (81.81%) out of 11 patients. Endobronchial coils did not have a favorable outcome in our study with a failure rate of 40%. We recommend using endobronchial coils, Bioglue, and sealants for air leaks <4 mm.[2,8,10,14] We successfully used self-expanding metallic stents and atrial septal occluder devices for closure of larger BPFs. Overall bronchoscopic intervention to manage BPFs can be a successful strategy and may be tried as an option before subjecting the patient to redo surgery.

None of the patients experienced adverse events such as massive hemorrhage, device displacement, or local infection. In patients, where we used a covered tracheobronchial self-expanding metallic stent, regular follow-up and domiciliary steam inhalation were ensured for optimal secretion management. One limitation of our study is that the sample size was small and to establish a definite conclusion, we need to have a larger series with longer follow-up duration of patients.

CONCLUSION

Bronchopleural fistula is a common complication after thoracic surgery and is fraught with significant morbidity and mortality among patients. Bronchoscopic device closure of these fistulae can successfully be done utilising

devices like stents, occluder devices and endobronchial coils. The device is chosen after meticulous evaluation and based upon the size and location of the airleak. Overall, these devices provide an effective, quick and minimally invasive means for bronchoscopic closure of BPF with minimal complications

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Pforr A, Pagès PB, Baste JM, Thomas P, Falcoz PE, Lepimpec Barthes F, *et al*. A predictive score for bronchopleural fistula established using the French database Epithor. Ann Thorac Surg 2016;101:287-93.
2. Lois M, Noppen M. Bronchopleural fistulas: An overview of the problem with special focus on endoscopic management. Chest 2005;128:3955-65.
3. Rivera C, Bernard A, Falcoz PE, Thomas P, Schmidt A, Bénard S, *et al*. Characterization and prediction of prolonged air leak after pulmonary resection: A nationwide study setting up the index of prolonged air leak. Ann Thorac Surg 2011;92:1062-8.
4. Okuda M, Go T, Yokomise H. Risk factor of bronchopleural fistula after general thoracic surgery: Review article. Gen Thorac Cardiovasc Surg 2017;65:679-85.
5. Cardillo G, Carbone L, Carleo F, Galluccio G, Di Martino M, Giunti R, *et al*. The rationale for treatment of postresectional bronchopleural fistula: Analysis of 52 patients. Ann Thorac Surg 2015;100:251-7.
6. Dugan KC, Laxmanan B, Murgu S, Hogarth DK. Management of persistent air leaks. Chest 2017;152:417-23.
7. Wood DE, Cerfolio RJ, Gonzalez X, Springmeyer SC. Bronchoscopic management of prolonged air leak. Clin Chest Med 2010;31:127-33.
8. Lazarus DR, Casal RF. Persistent air leaks: A review with an emphasis on bronchoscopic management. J Thorac Dis 2017;9:4660-70.
9. Liberman M, Muzikansky A, Wright CD, Wain JC, Donahue DM, Allan JS, *et al*. Incidence and risk factors of persistent air leak after major pulmonary resection and use of chemical pleurodesis. Ann Thorac Surg 2010;89:891-7.
10. Sarkar P, Chandak T, Shah R, Talwar A. Diagnosis and management bronchopleural fistula. Indian J Chest Dis Allied Sci 2010;52:97-104.
11. Fruchter O, Bruckheimer E, Raviv Y, Rosengarten D, Saute M, Kramer MR. Endobronchial closure of bronchopleural fistulas with Amplatzer vascular plug. Eur J Cardiothorac Surg 2012;41:46-9.
12. Gogia P, Gupta S, Goyal R. Bronchoscopic management of bronchopleural fistula. Indian J Chest Dis Allied Sci 2010;52:161-3.
13. Chae EY, Shin JH, Song HY, Kim JH, Shim TS, Kim DK. Bronchopleural fistula treated with a silicone-covered bronchial occlusion stent. Ann Thorac Surg 2010;89:293-6.
14. Katoch CD, Chandran VM, Bhattacharyya D, Barthwal MS. Closure of bronchopleural fistula by interventional bronchoscopy using sealants and endobronchial devices. Med J Armed Forces India 2013;69:326-9.
15. Ryan B, Yendamuri K, Yendamuri S. Anatomical considerations in bronchoscopy. J Thorac Dis 2017;9:S1123-S1127.
16. Marwah V, Ravikumar R, Rajput AK, Singh A. Transcutaneous closure of chronic broncho-pleuro-cutaneous fistula by duct occluder device. Lung India 2016;33:216-8.
17. Marwah V, Rajput AK, Madan H, Garg Y. Closure of chronic bronchopleural fistula using atrial septal occluder device. J Bronchology Interv Pulmonol 2014;21:82-4.
18. Fruchter O, Kramer MR, Dagan T, Raviv Y, Abdel-Rahman N, Saute M, *et al*. Endobronchial closure of bronchopleural fistulae using Amplatzer devices: Our experience and literature review. Chest 2011;139:682-7.
19. Fruchter O, El Raouf BA, Abdel-Rahman N, Saute M, Bruckheimer E, Kramer MR. Efficacy of bronchoscopic closure of a bronchopleural fistula with Amplatzer devices: Long-term follow-up. Respiration 2014;87:227-33.
20. Han X, Yin M, Li L, Zhu M, Ren K, Qi Y, *et al*. Customized airway stenting for bronchopleural fistula after pulmonary resection by interventional technique: Single-center study of 148 consecutive patients. Surg Endosc 2018;32:4116-24.
21. Chawla RK, Madan A, Bhardwaj PK, Chawla K. Bronchoscopic management of bronchopleural fistula with intrabronchial instillation of glue (N-butyl cyanoacrylate). Lung India 2012;29:11-4.
22. Scordamaglio PR, Tedde ML, Minamoto H, Assad RS, Fernandes PMP. Can total bronchopleural fistulas from complete stump dehiscence be endoscopically treated? Eur J Cardiothorac Surg 2017;51:702-8.
23. Folch E, Keyes C. Airway stents. Ann Cardiothorac Surg 2018;7:273-83.
24. Bolliger CT, Sutedja TG, Strausz J, Freitag L. Therapeutic bronchoscopy with immediate effect: Laser, electrocautery, argon plasma coagulation and stents. Eur Respir J 2006;27:1258-71.
25. Watanabe S, Shimokawa S, Yotsumoto G, Sakasegawa K. The use of a Dumon stent for the treatment of a bronchopleural fistula. Ann Thorac Surg 2001;72:276-8.
26. Tsukada H, Osada H. Use of a modified Dumon stent for postoperative bronchopleural fistula. Ann Thorac Surg 2005;80:1928-30.
27. Takahashi M, Takahashi H, Itoh T, Nomura M, Ogata A, Maehara S, *et al*. Ultraflex expandable stents for the management of air leaks. Ann Thorac Cardiovasc Surg 2006;12:50-2.
28. de Lima A, Holden V, Gesthalter Y, Kent MS, Parikh M, Majid A, *et al*. Treatment of persistent bronchopleural fistula with a manually modified endobronchial stent: A case-report and brief literature review. J Thorac Dis 2018;10:5960-3.
29. Bellato V, Ferraroli GM, De Caria D, Infante MV, Cariboni U, Spoto MR, *et al*. Management of postoperative bronchopleural fistula with a tracheobronchial stent in a patient requiring mechanical ventilation. Intensive Care Med 2010;36:721-2.
30. Andreetti C, D'Andrilli A, Ibrahim M, Ciccone AM, Maurizi G, Mattia A, *et al*. Effective treatment of post-pneumonectomy bronchopleural fistula by conical fully covered self-expandable stent. Interact Cardiovasc Thorac Surg 2012;14:420-3.
31. Dutau H, Breen DP, Gomez C, Thomas PA, Vergnon JM. The integrated place of tracheobronchial stents in the multidisciplinary management of large post-pneumonectomy fistulas: Our experience using a novel customised conical self-expandable metallic stent. Eur J Cardiothorac Surg 2011;39:185-9.