Review Article

Advances in Bronchoscopy — Therapeutic Bronchoscopy

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Abstract

The common indications for therapeutic bronchoscopy include relief of benign and malignant airway stenosis, in the intensive care unit, foreign body removal and management of hemoptysis. Debulking of airway tumors may be undertaken using techniques such as laser photoresection, electrocautery, cryotherapy, argon plasma coagulation or mechanically using rigid bronchoscopy. These techniques are often used in combination. Balloon dilatation and insertion of silicone or metallic airway stents can be undertaken to treat benign and malignant strictures or bronchomalacia. Airway stents maintain luminal patency by opposing extrinsic compressive forces or by providing internal support. Certain stent types may also physically prevent (Silicone and covered metallic stents) the encroachment of tumor tissue into the airways. Covered metallic airway stents are safe and effective in the management of malignant tracheoesophageal fistulae, reduce the risk of recurrent aspiration and provide enhanced quality of life by allowing resumption of oral nutrition. In this article, we present an overview of application and the current methods available to perform therapeutic bronchoscopy. ©

Introduction

Interventional bronchoscopy refers to the application of advanced bronchoscopic techniques for the diagnosis and treatment of various diseases of the airways. Central airway obstruction from malignant or benign endobronchial tumor can result in respiratory failure, and urgent relief of obstruction may be necessary for symptomatic relief, to avoid mechanical ventilation or facilitate weaning. As there are no randomized trials comparing efficacy between different therapeutic modalities, selection of treatment strategy depends on acuity of presentation, type of lesion, stage of disease, patient's general status and physician expertise.[1] One of the commonest application of therapeutic flexible bronchoscopy is in the intensive care unit for mucus plugging. In this article, we present an overview of interventional therapeutic bronchoscopy and a brief discussion on the role of bronchoscopy in the intensive care unit.

Rigid Versus Flexible Bronchoscope

Rigid bronchoscopy was first invented by Gustav Killian in the 19th century and the primary indication was to remove a pork bone, which had been aspirated into the right main bronchus.[2] Since then therapeutic indications for bronchoscopy have expanded to include relief of tracheobronchial stenosis, whole lung lavage, bronchoscopic guided endotracheal intubation and percutaneous tracheostomy.

The invention of the flexible bronchoscope (FB) by Shigeto Ikeda in 1970 revolutionized the practice of diagnostic and therapeutic pulmonary medicine.[3] In the following 30 years, FB has supplanted the rigid bronchoscope as the instrument of choice for most diagnostic and therapeutic procedures in adults. A recent survey by Colt and Prakash showed that 99% of all bronchoscopies in the United States were performed with FB, and only 4% of respondents reported experience in rigid bronchoscopy.[4] Moreover many training programs limit exposure of the pulmonary trainees to only flexible instruments.[5] Although the versatility of FB has replaced rigid bronchoscopy in many indications, rigid bronchoscopy remains an invaluable tool in adult and pediatric bronchology. It's application should be considered for better control of compromised airway, massive hemoptysis, silicone stent placement, and removal of large foreign bodies.

Malignant Airway Obstruction

Tumor debulking using rigid bronchoscopy

For life-threatening tracheobronchial obstruction, rigid bronchoscopic recanalization is the treatment of choice. The beveled tip of the rigid bronchoscope is ideal for coring

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through large airway tumors and dilating strictures. The large internal diameter of the rigid bronchoscope facilitates debridement of tumors, evacuation of clots and ventilation.[6] This approach is often combined with the laser photo resection (LPR) therapy.

Laser photoresection

Neodymium-Yttrium-Aluminum-Garnet (Nd-YAG) laser is most commonly used bronchoscopically and has a penetration of 3 to 5 mm in depth. It is indicated in patients who have a symptomatic and unresectable exophytic airway lesion. The lesion best suited for LPR is an endobronchial tumor that measures ≤ 4cm, arises from one wall of the trachea or main stem bronchus, with visible distal lumen and lung collapse ≤ 6 weeks (Fig. 1).[7] Lesions involving the esophagus or pulmonary vessels are contraindicated for the risk of fistula formation. LPR of submucosal lesions or those that compress the airway extrinsically have the risk of airway perforation. Other contraindications include abnormal coagulation profile, unstable cardiovascular status and high oxygen requirement.[7]

LPR has been reported to improve airway patency in 79% to 92% of patients.[8,9] It's coagulative property is also useful in the palliation of hemorrhagic endobronchial tumors. LPR is therefore very effective in relieving symptoms of cough, dyspnea and hemoptysis as well as in achieving endoscopic, radiographic, spirometric and quality-of-life improvements.[10-13] It may also obviate the need for mechanical ventilation in selected patients with respiratory distress and also help to facilitate weaning and extubation in those receiving mechanical ventilation.[14,15] Survival benefit due to LPR is uncertain owing to lack of randomized trials. Studies demonstrating increased survival with LPR include; Brutinel et al, who reported a survival rate of 60% at 7 months among patients treated with LPR compared with none in the historical group; Eichenhorn *et al*, who demonstrated a longer median survival among those who underwent LPR (340 days) compared with controls (198-266 days) who received external beam irradiation alone, and Shea *et al*, who found additional benefit when brachytherapy was administered with LPR.[16-18] There are also other studies, which have not shown any benefit from LPR.[19,20] The factors favoring the use of LPR include, immediate relief of dyspnea, improved performance and better quality of life. LPR is often used complementary to external beam radiation, chemotherapy, stenting or surgery and often may be the only means of palliative treatment.

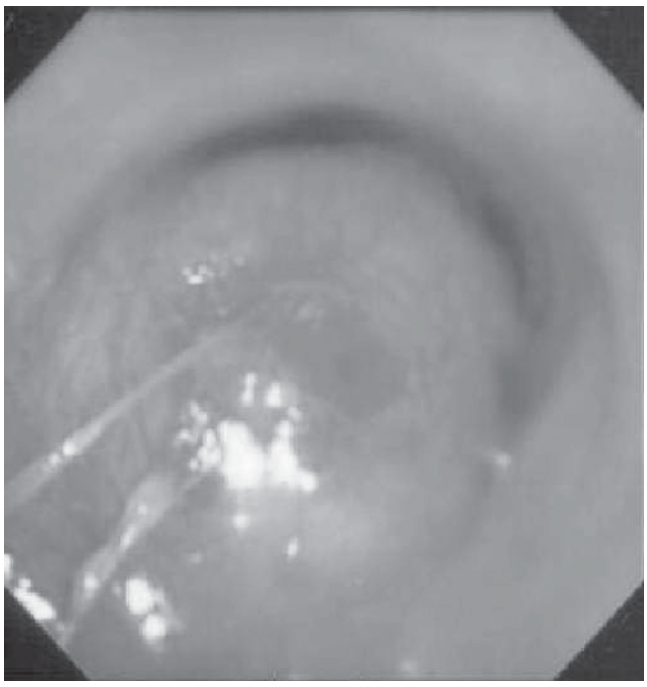

Fig. 1: An ideal exophytic tumor for laser photoresection.

Complication rates up to 2.2% have been reported.[10,21,22] The most serious complication is the perforation of major intrathoracic blood vessel, followed by pneumothorax or pneumomediastinum secondary to perforation of the airway wall and endobronchial ignition.[7,23-25] Combustible anesthetic agents should not be used. Occasionally, when FB is being used, rigid bronchoscopy may be required for suction and tamponade of the site if bleeding becomes excessive. The composition of laser plume has also come under investigation following reports, which demonstrate intact human papillomavirus (HPV) DNA in the vapors of laser-treated verrucae and subsequent development of similar lesions in the treating physicians. DNA of the human immunodeficiency virus (HIV) has also been detected in laser smoke but culture of the virus in cells did not occur.[26-28] Special protective masks and smoke evacuator during LPR for high-risk patients are therefore recommended.

Electrosurgery

Endobronchial electrosurgery (EBES) is the application of electrical current to coagulate or vaporize tissue in the tracheobronchial tree. EBES is being increasingly applied for the treatment of lung cancer due to the development of grounded bronchoscopes, better probes, high frequency electric generators and low equipment and maintenance costs.[29] EBES is performed by direct contact of the probe, which allows cut, blend and coagulation of target tissue by adjusting the amperage and voltage of current. EBES has been used successfully to debulk tracheobronchial tumors and restore airway patency in 70% to 86% of patients.[30] Experience in early lung cancer is however limited. A pilot study examining the efficacy of EBES in 13 patients with superficial early squamous cell carcinomas and in-situ carcinomas measuring not more than 1 cm^2 surface area has demonstrated a long-term response in 10 patients.[31] Although the number of patients is small, results imply at least comparable efficacy of EBES with PDT and brachytherapy in the treatment of early lung cancer. Hemorrhage from vascular tumors, airway fire and respiratory failure can occur during EBES.[32,33]

The argon plasma coagulator (APC) is an example of non-contact EBES, and uses ionized argon gas as a conductor for electrical current between the electrode and tissue.[29] It is ideal for coagulation of superficial hemorrhagic lesions, tumors of the upper lobe segmental or superior basal lobar bronchi as well as stent-related obstructive granuloma.[34,35] The in-depth

tissue necrosis achieved with APC is less compared with Nd-YAG laser, brachytherapy, and photodynamic therapy (PDT).[29]

Brachytherapy

Endobronchial brachytherapy is a form of local radiation treatment, which involves temporary placement of encapsulated radioactive sources within or near the tumor. The advantages of brachytherapy over external beam radiation include: (1) delivery of a higher dose of radiation directly to tumor; (2) rapid fall of radiation outside treatment region; (3) precise dose localization, and (4) adaptability to tumor shape. It is often used in patients who have received their maximal dose of external beam radiotherapy to the target area. Patients with endobronchial tumors from primary or secondary lung cancer and residual tumor following surgery are candidates for brachytherapy. However, the lesion to be treated must be visible on bronchoscopy, permit the passage and distal placement of catheter, and located in the trachea, mainstem or lower bronchi. Outcome studies with low dose rate and high dose rate brachytherapy revealed similar endobronchial response rates of 60-90% and comparable survival rates.[36-38] Response to brachytherapy correlated with tumor size and good results were observed with small endobronchial lesions.[39,40] Endobronchial brachytherapy may require multiple treatments to be effective. It is often used in combination with LPR for quicker restoration of airway patency or conventional external beam radiotherapy for better local cancer control and lower radiation dose to surrounding normal lung.[41,42] Brachytherapy may also be administered after stent placement for patients with extrinsic airway compression due to malignant tumors or for the prevention and treatment of airway stenosis due to recurrent growth of granulation tissue in patients with lung transplants.[43]

Respiratory compromise, massive hemoptysis, fistula formation, radiation bronchitis, airway stenosis and erosion of the pulmonary artery have been reported with brachytherapy.[44,45] Bedwinek *et al*, showed a 32% rate of massive hemoptysis in, patients with recurrent tumors of the right upper lobe, right mainstem, and left upper lobe bronchi.[44] Radiation induced bronchitis and stenosis has been reported in 8.7% patients, which was observed more commonly with tumors in the trachea and mainstem bronchi, administration of high total radiation dose for curative intent, and a good Karnofsky performance score.[45]

Cryotherapy

Cryotherapy acts by causing local tissue destruction through hypothermic cellular crystallization and microthrombosis by application of extremely low temperatures (-20 to -40 degree Celsius).[46] Tumor cells are more cryosensitive than normal cells, while certain tissues such as fat, cartilage, fibrous tissue or connective tissue are cryoresistant.[46] The most common indication for cryotherapy is to relieve airway obstruction caused by benign or malignant tumors. Unlike LPR and EBES which achieve rapid airway recanalization, endobronchial cryotherapy is ineffective in removing tissue rapidly and cannot be the treatment of choice for the patient having life threatening tracheobronchial obstruction. Cryotherapy is successful 50%-86% in relieving airway obstruction and a synergistic response with chemotherapy and radiotherapy has been observed.[47-50] Repeat bronchoscopy is usually performed 8 to10 days following cryotherapy to clean up sloughed tissue or for repeat treatment of large lesions. Cryotherapy can also be used to treat granulation tissue and web-like stenosis as well as for the removal of foreign bodies, mucus plugs and blood clots.[51] Its role in the management of early lung cancer is still under investigation.[52] The most serious complication is hemorrhage, although pneumothorax, tracheoesophageal fistula, dysrrhythmia and bronchospasm have also been reported with endobronchial cryotherapy.[51,53]

Photodynamic therapy

Photodynamic therapy (PDT) is a two-step process that involves the intravenous administration of a photosensitizing agent known as dihematoporphyrin ether / ester (DHE, Photofrin II) and exposure to argon pump-dye laser. Following the administration of DHE, which is preferentially retained by tumor cells, and cleared from most healthy tissues within 6 hours except for the lung, reticuloendothelial tissues and the skin, the tumor is exposed to 630 nm wavelength of laser light introduced via FB 24 to 48 hours later. This results in tumor necrosis from cellular destruction by superoxide and hydroxyl radicals as well as vascular occlusions from release of thromboxane A2.[54] Clean-up bronchoscopy is often necessary 2 to 4 days after the procedure.

PDT is indicated for the palliation of advanced obstructing cancers of the tracheobronchial tree.[55,56] Moghissi *et al*, reported that the mean endoluminal obstruction of 100 patients treated with PDT improved by 68%, with corresponding increases in FVC and FEV_1.[57] Median survival of advanced lung cancer treated with PDT was also shown to be better than with other treatment modalities.[58] Other indications for PDT include treatment of synchronous and early lung cancers.[59-61] Median survival for patients with synchronous lung cancers treated with PDT alone or in combination with surgery was 52 months. Moreover PDT used preoperatively reduced the extent of surgical resection in some patients.[62] Surgery is advocated for treatment of early lung cancer, but in high surgical risk patients or in those who refuse surgery, PDT may represent an alternative treatment of cure if the cancer satisfies these criteria: 1) roentgenographically occult, 2) superficial, < $3cm^2$ in surface area and < 1mm in depth, and 3) squamous cell carcinoma. The overall complete remission rate with PDT in this group is between 64% and 98%.[60,61]

Distal lobar obstructions not amenable to LPR can be treated with PDT. Disadvantages of PDT include slow onset of action (thus not useful for patients with acute respiratory distress), the need to avoid sunlight for 4 to 6 weeks, and frequent clean-up bronchoscopies. Complications include dyspnea from airway obstruction due to tissue swelling and edema, photosensitivity and hemoptysis.

Airway stents

Stent insertion for malignant tracheobronchial obstruction following LPR or electrocautery results in immediate relief of acute respiratory distress, successful extubation, and prolonged survival.[15,63] Various stent types are available for palliation of both benign and malignant airway stenosis (silicone - Dumon stent; metallic - Ultraflex stents).[64-67] The Dumon stent is inserted using the rigid bronchoscope and has probably been the most common silicone stent used in the last decade (Fig. 2).[64] The advantages include that it can be easily repositioned or removed, it provides a solid barrier to prevent encroachment of tumor and is relatively cheaper than the metallic stents. The disadvantages of this stent type include its tendency to migration, relatively unfavorable wall-to-lumen ratio, mucous retention, lack of flexibility in conforming to tortuous airways and the possibility to stimulate formation of granulation tissue.[68] Advantages of covered metallic stents for malignant tracheobronchial obstruction are ease of placement, greater airway cross-sectional diameter, better conformity to tortuous airways, dynamic expandability, visibility on the radiograph or during fluoroscopy and maintenance of mucociliary clearance (uncovered stent). Ventilation across a lobar bronchial orifice can also be maintained with an uncovered stent or in some cases when the lower or the upper uncovered part of a covered stent covers the lobar orifice. Disadvantages include granuloma formation and difficulty in removal and repositioning due to stent epithelialization.[69,70] Fatal complications following airway and large vessel perforation have been reported with the use metallic stents.[66]

The Wallstent, which was popular in the later half of the last decade, is a self-expandable wire mesh of cobalt-based superalloy monofilaments. Obstructive granuloma was observed in 11% of 37 patients who received 52 Wallstents for malignant and benign strictures, but none had stent migration or mucus plugging.[71] The Ultraflex stent, made of nitinol, a nickel titanium alloy is currently the metallic stent of choice and available in covered and uncovered forms (Fig. 3).[67] Miyazawa *et al* reported no occurrence of retained

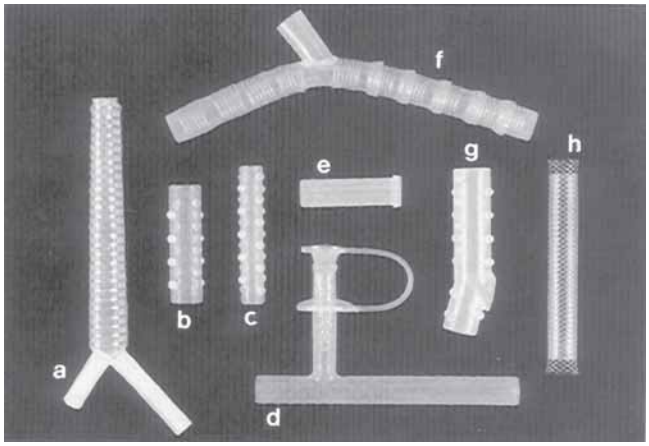

Fig. 2 : Various types of airway stents. a - Dynamic 'Y' stent; b to g - Dumon stent; h - covered wallstent (metallic stent with polyurethane coating).

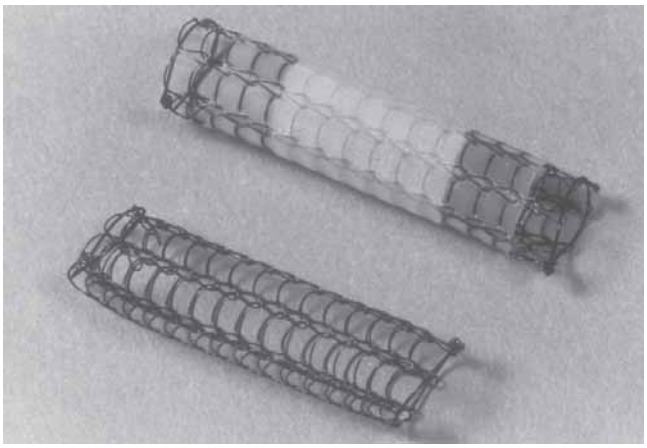

Fig. 3 : Covered and Uncovered Ultraflex stents.

secretions or stent migration in the 34 patients who received 54 uncovered Ultraflex stents for inoperable malignant airway stenoses.[65] Although literature on the long-term complications is limited, given its excellent flexibility and biocompatibility, the Ultraflex stent may prove to be a good prosthesis for complex malignant airway lesions.[72] Tracheoesophageal fistulae occur in 5 to 15% of patients with esophageal malignancy and are associated with significant morbidity from recurrent aspiration and malnutrition. Covered metallic airway stents are safe and effective in the management of malignant tracheoesophageal fistulae, reduce the risk of recurrent aspiration and provide enhanced quality of life by allowing resumption of oral nutrition.[73]

Benign Airway Obstruction

Benign tracheobronchial stenosis in the adult patient can be a complication of a variety of diseases that include tuberculosis, sarcoidosis, trauma, following endotracheal intubation, lung transplantation, tracheostomy or bronchial sleeve resection, post-radiation or fibrosing mediastinitis.[74-77] It is estimated that fifty-percent or more patients treated with balloon dilatation may not need any other form of therapeutic intervention and hence it may be a reasonable first option to restore airway lumen in benign stenosis.[75,76] Other techniques such as LPR, EBES, APC and cryotherapy can also be used to relieve airway obstruction due to benign tumor, obstructive granuloma, and stenosis.

LPR is commonly used to treat benign endobronchial lesions such as hemangiomas, lipomas, myoblastomas, chondromas, leiomyomas, histiocytomas and hamartomas.[21,22] Symptomatic obstructive granulomas due to mechanical trauma from endotracheal intubation, foreign body, tracheostomy tube, transtracheal oxygen catheter, suture material, and inflammatory processes such as Wegener's granulomatosis or sarcoidosis, can be removed by LPR, APC, EBES or cryotherapy. Subglottic or tracheal stenosis poses a therapeutic dilemma and challenge, to the pulmonolgist as non-surgical endoscopic attempts at dilatation, EBES, cryosurgery or LPR may not be always successful. Laryngotracheal resection or reconstruction, although

successful, can cause damage to vocal cords and recurrent laryngeal nerve.[78] Mehta *et al*, reported a success of 67% for subglottic and tracheal stenoses treated with mucosal-sparing Nd-YAG LPR, dilatation with balloon or single size rigid bronchoscope, and stenting if malacia was observed.[79] If stenosis recurred after the three attempts at bronchoscopic treatment, patient was referred for definitive surgical intervention.

Balloon bronchoplasty with the FB has largely replaced rigid bronchoscopic dilatation of airway stenosis. It's use is often combined with laser bronchoscopy and stent placement to treat strictures due to tuberculosis, fibrosing mediastinitis, prolonged intubation, and lung transplantation.[75,77] For stenotic lesions in lung transplant recipients, balloon dilatation has been recommended on at least two occasions prior to stent insertion or more than two occasions if required in the presence of significant inflammation as it may avoid the need for stent placement in up to 25% patients.[66] In the presence of inflammation balloon dilatation allows time for an inflammatory stricture in lung transplant recipients to mature into a fibrous stricture, which is more suitable for stent placement.[66,77] Dilatation of airway stenosis before stent placement also allows the assessment of the extent of the lesion, the degree of inflammation, and the status of the bronchial tree distal to the stenosis.[77] In lung transplant recipients with stenotic lesions, it is recommended that balloon dilatation should be performed at least twice prior to stent placement. Complications of balloon bronchoplasty include bronchospasm, chest pain, airway perforation, pneumothorax, and pneumomediastinium.[76,80,81] Stent insertion is often undertaken in lung transplant recipients having large airway stenosis.[66,67] With time uncovered metallic stents get incorporated into the airway wall and are difficult to remove. However, silicone stents do not get embedded into the airway wall and therefore can be removed at a later date after insertion.

Bronchoscopy In Intensive Care Unit

Retained Secretions and Atelectasis

Despite widespread acceptance of bronchoscopic suction as treatment for retained secretions and atelectasis, its superiority over chest physiotherapy has not been clearly established.[82-84] Although studies showed that FB suction for whole lung collapse and lobar atelectasis resulted in better oxygenation in 44% and radiological improvement in 88%, Marini *et al*, found no difference in extent of radiological improvement between therapeutic FB and chest physiotherapy for post-operative lobar atelectasis.[82-84] However, therapeutic FB may be life saving for some patients, and should not be withheld because of hypoxia.[85] Moreover, clearing thick mucous plugs and secretions by FB suction may facilitate weaning of asthmatics from mechanical ventilation.[86,87]

Endotracheal Intubation

FB can be used to guide placement of oral or nasal endotracheal tubes in patients with compromised upper airways or in those with restricted neck mobility.[88] It also facilitates change of endotracheal tubes without losing control of the airways, placement of double lumen endobronchial tubes for either one lung or two-lung ventilation and difficult nasogastric intubation.[89-91] In addition, jet ventilation can be applied through the working channel of FB to ensure ventilation of anesthetized and paralyzed patients until the airways are secured.[92]

Percutaneous Dilatational Tracheostomy

This is a bedside technique that consists of percutaneous needle puncture of the trachea, followed by step-wise dilation and placement of tracheostomy tube.[93] A CXR is performed after the procedure to confirm position of tracheostomy tube and to check for complications. Indications for a percutaneous dilatational tracheostomy are similar for surgical/open tracheostomy. Advantage of bed side percutaneous dilatational tracheostomy include obviating the need for transport of critically ill patients to the operating room, use of a smaller skin incision and a reduced risk of major hemorrhage and late sequelae such as subglottic stenosis.[94] Skin infection, unstable cervical spine and increased intracranial pressure are absolute contraindications for percutaneous dilatational tracheostomy, while high ventilatory requirements, coagulopathy, marked obesity and anatomic abnormality (goitre) are relative contraindications.[95] Complications include hemorrhage, mucosal tears, submucosal tunnelization of tracheal wall, perforation of posterior tracheal wall causing tracheoesophageal fistula, paratracheal insertion, barotrauma (pneumothorax, pneumomediastinum, subcutaneous emphysema), endotracheal tube and FB damage, stomal infection and early dislodgement.[96,97] Hazard and coworkers have demonstrated a higher complication rate with surgical tracheostomy (45.8%) than with percutaneous dilatational tracheostomy (12.5%) and an increased occurrence of delayed stomal healing and significant subglottic stenosis (88% versus 27% respectively).[98] Accidental decannulation was also observed more frequently in surgical tracheostomy group (41%) than percutaneous dilatational tracheostomy (12%).[99]

Adult Airway Foreign Body Removal

Advances in bronchoscopy, have lead to a reduction in the morbidity and mortality from foreign body aspiration. The first foreign body was removed with a rigid bronchoscope. With advances in technology, now it is also possible to remove foreign bodies using a flexible bronchoscope.[100,101] Flexible bronchoscopy also has the advantage that it can be performed in an outpatient setting with the patient under local anesthesia.[100,101] However, rigid bronchoscopy back up is desirable if flexible bronchoscopic removal of a foreign body fails. The accessories available for foreign body retrieval via FB include grasping forceps, baskets, multi-pronged snares, magnet extractor and balloon catheters.[101] Cryoprobes have also been used for foreign body extraction.

Therapeutic whole lung lavage

Pulmonary alveolar proteinosis (PAP) characterized by the

accumulation of proteinaceous material in the alveoli is a rare disease, associated with defective function of alveolar macrophages, abnormal surfactant proteins, cytokine imbalance and defective expression of granulocyte-macrophage colony stimulating factor (GM-CSF) or its receptors on alveolar macrophages and type-II pneumocytes.[102-105] Therapeutic whole-lung lavage (either one lung or sequential 2 lung lavages per anesthesia session) is considered to be the most effective treatment for PAP as it not only mechanically removes the lipoproteinaceous material through repeated dilution with saline solution, including removal of anti-GM-CSF antibody, but also possible immunologic effects on the alveolar macrophages and type-II pneumocytes.[106] Hypoxemia and hemodynamic instability can occur during whole-lung lavage.[107] Segmental or lobar lavage is reported as a therapeutic alternative, but requires special equipment such as cuffed bronchoscopic catheter with fluoroscopy or modified bronchoscope with inflated tracheostomy cuff or trypsin as lavage fluid.[108-110]

Mediastinal Cysts and Lung Abscesses

Mediastinal cysts represent 9% of all primary mediastinal masses in surgical series.[111,112] These malformations can be divided into bronchogenic cysts, esophageal duplications and neurenteric cysts. Bronchogenic cysts are the most common, accounting for 54% to 63% and are usually located in the subcarinal or paratracheal area.[112,113] Most mediastinal cysts are detected as incidental findings on routine CXR or esophagrams, however, compressive symptoms such as stridor, dyspnea, persistent cough or dysphagia can occur. CT plays an important role not only in differentiating a benign cyst from mediastinal malignancy but also a road map for the bronchoscopist to perform transtracheal or transbronchial needle aspiration for diagnostic or therapeutic indication.[114] Bronchoscopic aspiration of mediastinal cysts could potentially avoid the need for mediastinoscopy or thoracotomy. Treatment for lung abscess includes antibiotics, chest physiotherapy, and surgery where conservative measures fail. Bronchoscopic placement of an indwelling catheter into abscess cavity is a non-invasive alternative, as it not only allows for aspiration of pus for culture but also drainage and irrigation of abscess. This method has been reported to obviate the need for surgery, however care to avoid spillage of pus into airways must be exercised.[115] However, there are limited data about the therapeutic application of the FB techniques for these indications and none of the authors have first hand experience for these indications.

Massive Hemoptysis

Massive hemoptysis, defined as the volume of expectorated blood that is life-threatening due to hypoxia from airway obstruction or hemodynamic instability from blood loss, accounts for 4.8% to 14% of all patients with hemoptysis.[116] Although issues such as optimal timing of bronchoscopy and preferred instrument (rigid versus flexible bronchoscopy) in the initial assessment remain controversial, early FB may be undertaken as the first step in most cases of hemoptysis it allows better localization of site of hemorrhage as well as institution of endoscopic measures to arrest bleeding.[117] If indicated, rigid bronchoscopy is the procedure of choice when patient has massive hemoptysis.

Endobronchial tamponade can be performed by wedging the tip of FB into the bleeding segment, followed by inflation of a balloon catheter, which is introduced through the working channel. FB is removed over the catheter and the balloon is left inflated in the bronchus for 24 hours. FB is performed the next day and if no further bleeding is observed after deflation of balloon, the catheter is removed.[118] Although no complications have been reported with this technique, extended use of balloon tamponade catheters may result in mucosal ischemic injury and post-obstructive pneumonia.[118,119] Modifications of this technique using a J-guide wire to insert a balloon catheter in the bleeding segment has also been described.[120] A double lumen bronchus blocking catheter which has an inner channel for instillation of cold saline, epinephrine and thrombin/thrombin-fibrinogen solutions, an inflatable balloon at the tip and a detachable valve may also be used. This catheter can be introduced via the working channel of FB and wedged in the bleeding segment for several days without complications, while the patient receives definitive therapy.[121]

Other uses of FB include administration of surfactant and liquid ventilation for patients with acute respiratory distress syndrome, N-acetylcysteine for mucous plugging and instillation of fibrin glue into affected bronchial segment as treatment for persistent bronchopleural fistula.[86,122,123]

Conclusion

Therapeutic bronchoscopy offers effective methods in the palliation of lung cancer especially in alleviating dyspnea, controlling hemoptysis, and improving the quality of life. It may also help in avoiding mechanical ventilation in patients with respiratory distress, facilitate weaning, and allow time for the institution of external beam radiotherapy and chemotherapy. In a select group of patients with early lung cancer, they may represent alternative treatment modalities. Therapeutic bronchoscopy continues to play a pivotal role in foreign body retrieval, whole lung lavage for pulmonary alveolar proteinosis, difficult intubation, percutaneous tracheostomy, treatment of lobar atelectasis as well as administration of surfactant for ARDS or mucolytics for status asthmaticus. It is our opinion that bronchoscopy of the new millennium will not only expand in its diagnostic and therapeutic applications, but is likely to assume greater importance as a means of delivery for gene therapy.

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