Literature Review

Role of Interventional Pulmonology in Palliative Care

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Abstract

Interventional pulmonology (IP) is a minimally invasive approach that plays a pivotal role in the evaluation and management of advanced thoracic diseases within palliative care. By integrating bronchoscopic and pleural techniques, IP provides effective symptom relief without the need for extensive surgical procedures or prolonged hospitalization. In malignant central airway obstruction, stenting, cryotherapy, and laser debulking offer rapid improvement in airflow and quality of life. For malignant pleural effusion, thoracentesis, pleurodesis, indwelling pleural catheters, and intrapleural fibrinolytic therapy for septated effusions provide safe and cost-effective strategies for symptom control. In selected cases of severe emphysema, bronchoscopic lung volume reduction using endobronchial valves improves lung mechanics and exercise capacity. In contrast, one-way endobronchial valves and spigots are valuable in managing persistent air leaks. With high procedural success rates and favorable safety profiles, IP is broadly applicable across diverse palliative respiratory conditions. Overall, IP provides a safe, effective, and patient-centered solution that complements standard palliative care, ensuring optimal quality of life while minimizing invasive burden.

Keywords: airway obstruction, bronchoscopic intervention, interventional pulmonology, lung volume reduction, malignant pleural effusion, palliative care

INTRODUCTION

Palliative care is a holistic approach that aims to improve the quality of life of patients with life-limiting illnesses by preventing and alleviating physical, psychological, and spiritual suffering. In patients with chronic respiratory diseases such as lung cancer, chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), persistent air leak (PAL), and drug-resistant tuberculosis, symptoms such as dyspnea, cough, and chest pain are common and often debilitating. These conditions are usually considered terminal diseases, with many patients eventually requiring comprehensive end-of-life care. If left untreated or inadequately managed, they can lead to significant morbidity and mortality.[1]

The global burden of lung cancer and advanced chronic lung diseases continues

to rise, driving an increasing demand for palliative care services. According to the World Health Organization, Asia remains the region with the highest burden of lung, tracheal, and bronchial cancers. In 2022, these cancers accounted for an estimated 1,566,355 new cases, representing 63.1% of the global incidence across both sexes. Within South Asia, India recorded the highest number of lung cancer cases, with 81,748, followed by Indonesia with 38,904 cases.[2]

Beyond pharmacological and invasive strategies, supportive interventions such as pulmonary rehabilitation have also demonstrated benefits. A recent case report in Indonesia showed that incentive spirometry combined with aerobic exercise improved physical endurance in a patient with stage IV lung cancer receiving palliative care, highlighting the importance of multidisciplinary approaches to optimize quality of life even in advanced disease.[3]

Interventional pulmonology (IP), traditionally associated with diagnostic and therapeutic procedures, has evolved to encompass a wide range of minimally invasive techniques that offer substantial benefits in symptom management, particularly for patients with advanced disease. These approaches allow clinicians to diagnose and treat conditions that once required surgery, thereby expanding access to care for vulnerable or high-risk patients.

Interventional pulmonology now encompasses bronchoscopic interventions such as mechanical debulking, laser therapy, electrocautery, cryotherapy, stenting, and other ablative modalities, as well as pleural procedures including thoracentesis, chemical pleurodesis, indwelling pleural catheter (IPC) placement, and video-assisted thoracoscopic surgery (VATS). Additional techniques, such as the Endobronchial Watanabe Spigot (EWS®) for persistent air leak and lung volume reduction strategies—either surgical (LVRS) or bronchoscopic (BLVR)—further broaden the therapeutic capabilities of IP to provide effective palliation.

Thisreview explores the role of interventional pulmonology in palliative care, focusing on its applications in airway and pleural disease management and in improving symptom burden and quality of life. Emphasis is placed on bronchoscopic techniques, pleural interventions, and novel approaches such as bronchoscopic lung volume reduction, supported by current evidence and expert consensus. Literature for this review was identified primarily through PubMed and supplemented by relevant case reports, cohort studies, and current clinical guidelines on interventional pulmonology in palliative care.

INTERVENTIONAL PULMONOLOGY IN MALIGNANT CENTRAL AIRWAY OBSTRUCTION (MCAO)

Malignant central airway obstruction is a severe complication commonly seen in patients with advanced lung cancer or thoracic metastases, often leading to significant respiratory symptoms. Due to its non-specific clinical presentation, early diagnosis is challenging yet critical, as

timely intervention substantially influences prognosis. Bronchoscopy is a pivotal tool for both diagnosis and therapeutic relief, particularly in palliative settings.[4,5] Among histological subtypes, squamous cell carcinoma is most prevalent, followed by adenoid cystic carcinoma, small and large cell carcinomas, sarcoma, adenocarcinoma, and undifferentiated carcinoma.[6]

A wide range of bronchoscopic techniques, including mechanical debulking, laser therapy, electrocautery, cryotherapy, stenting, and other ablative procedures, can be tailored to individual patient anatomy and disease characteristics.[7] A comparative summary of the effectiveness, risks, and current evidence gaps across these bronchoscopic modalities is presented in Table 1.

Three stent types are commonly used in malignant central airway obstruction (CAO). Silicone stents are customizable and easy to remove, but require rigid bronchoscopy and carry a higher risk of granulation. Fully covered metallic stents are easier to deploy and prevent tumor ingrowth, although they may increase the risk of infection and limit ventilation.[8] Partially covered metallic stents improve ventilation and reduce migration, but allow tumor ingrowth at uncovered ends and can be more challenging to remove. Laser resection and electrocautery are particularly effective for achieving immediate tissue destruction, making them well-suited for relieving acute airway obstruction.[7]

Table 1. Effectiveness, Risks, and Evidence Gaps of Bronchoscopic Modalities in Malignant CAO

Modality	Effectiveness	Risks/ Complications	Evidence Gaps
Laser (Nd: YAG)[9]	Symptom improvement was reported in dyspnea (76%), hemoptysis (94%), and cough (75%); up to 55% of patients were rendered asymptomatic.	Pneumonia, hemorrhage/hemoptysis, respiratory failure, pneumothorax, fistula, airway rupture, arrhythmia, myocardial infarction, death	Limited long-term outcome and durability data; lack of comparative trials versus other thermal modalities
Electrocautery[10]	High immediate efficacy with symptom improvement and complete airway clearance reported in up to 94% of patients	Hemorrhage, airway perforation, airway fire, scarring or stenosis (rare; reduced with soft coagulation mode)	Evidence is primarily limited to case reports and small case series; no high-quality comparative studies are available.
Cryotherapy (probe/spray)[11]	Effective tissue destruction with reported diagnostic yields up to 76.9–85.9% in pooled analyses	Pneumothorax (~6.8%), severe bleeding (0.3%), rare mortality (0.1%)	Presence of publication bias; lack of large multicenter randomized trials; delayed clinical effect limits emergency use
Airway stenting[12]	Sustained airway patency with significant symptom improvement; median survival ~5.4 months, with marked reduction in dyspnea scores post-procedure	Pain, hemoptysis, mucus plugging, stent obstruction, migration, pneumothorax	Limited data on long-term durability; optimal patient selection and comparative effectiveness among stent types remain unclear

Technical success in therapeutic bronchoscopy is commonly defined as restoring at least 50% of the airway lumen, and most retrospective series report success rates approaching 90% when procedures are performed by experienced operators. Despite these encouraging outcomes, complication rates remain non-negligible. Reported adverse events include hypoxia, pneumothorax, bleeding, hypotension, stent migration, fractures, infection, and obstruction due to tumor regrowth or secretions.[7]

Higher complication risks are observed in urgent or emergent procedures, in patients with ASA class >3, repeat interventions, and those receiving moderate sedation. Mortality within 30 days is more likely in patients with Zubrod scores >1, high ASA classification, endoluminal or mixed obstruction, and in cases requiring airway stent placement. These findings underscore the importance of careful patient selection and highlight the need for more robust comparative data across available bronchoscopic modalities.[7]

INTERVENTIONAL PULMONOLOGY IN MALIGNANT PLEURAL EFFUSION (MPE)

Malignant pleural disease (MPD) encompasses conditions resulting from direct tumor invasion, distant metastases to the pleura, or primary pleural neoplasms such as malignant pleural mesothelioma. One of the most common and clinically significant manifestations of MPD is a malignant pleural effusion (MPE), characterized by the presence of malignant cells in the pleural fluid.[13]

Malignant pleural effusion significantly impairs patients' quality of life, contributing to dyspnea, chest discomfort, fatigue, and cachexia. Lung and breast cancers are the leading causes, accounting for more than 50% of MPE cases. Notably, around 15% of lung cancer patients initially present with MPE, and nearly half will develop pleural effusion during their disease course.[13]

The presence of MPE is associated with poor prognosis, with median survival ranging from 3 to 12 months.[14] Since no current intervention has demonstrated a survival benefit, the primary therapeutic objective is palliation of symptoms. A range of fluid management strategies is available, and the choice of intervention is guided by the patient's clinical status, lung re-expansion potential, and overall goals of care.[15–17]

In this context, pleuroscopy plays a central role within interventional pulmonology, providing minimally invasive access to the pleural space for both diagnostic and selected therapeutic purposes. Also known as medical thoracoscopy or local anesthesia thoracoscopy, pleuroscopy is primarily used to obtain parietal pleural biopsies in patients with undiagnosed pleural effusions, achieving diagnostic yields exceeding 90%. In addition, it allows therapeutic interventions such as talc insufflation for pleurodesis and indwelling pleural catheter placement, with

decortication reserved for carefully selected cases.[18]

Thoracentesis provides immediate symptom relief, especially in patients with limited functional status or short life expectancy, though its effects are often temporary.[16,19,20] For those with prolonged survival and re-expandable lungs, pleurodesis, either via chest tube or thoracoscopic talc poudrage, can prevent fluid reaccumulation.[21] In select cases, rapid pleurodesis may be achieved by combining thoracoscopic talc insufflation with tunnelled pleural catheter (TPC) insertion in a single procedure, aiming to shorten hospital stay and catheter duration.[22]

Beyond malignant effusions, pleurodesis is also recommended for recurrent secondary spontaneous pneumothorax, particularly in elderly or high-risk patients who are not surgical candidates. Talc slurry via chest tube is favored in guidelines for its practicality and safety, while poudrage remains an acceptable alternative.[23]

Indwelling pleural catheter (IPC) therapy has emerged as a widely accepted option for long-term outpatient fluid management. The IPC placement is performed under local anesthesia and moderate sedation using the modified Seldinger technique.[15,24,25] It is beneficial for patients with trapped lungs or who are unsuitable for pleurodesis.[15,26] In addition to continuous drainage, IPC may be combined with sclerosant instillation to induce pleurodesis.[27] While generally safe, IPC placement can be associated with complications such as infection, catheter blockage, tract metastasis, and pneumothorax.[28,29]

Video-assisted thoracoscopic surgery (VATS) talc poudrage enables controlled pleurodesis under direct visualization and allows for diagnostic pleural biopsy. The procedure involves atomizing 3–6 grams of sterile talc into the pleural space, followed by chest tube placement and negative pressure drainage. Although effective, VATS is generally reserved for patients with adequate performance status due to its invasive nature. Meta-analyses suggest comparable efficacy between VATS poudrage and talc slurry, with some favoring VATS in specific populations.[20]

In conclusion, MPE management is centered on individualized, symptom-driven strategies. The selection of an appropriate intervention should consider patient preferences, disease trajectory, and procedural risks. Interventional pulmonology offers diverse and effective options that can substantially improve comfort and reduce hospitalization in this vulnerable patient group.

In MPE, septations and high fluid viscosity can impair drainage and limit the effectiveness of standard interventions. Case evidence supports the use of intrapleural fibrinolytic therapy (IPFT) in these settings. Foo et al reported the successful use of repeated fibrinolysis over 12 months in a patient with recurrent viscous MPE managed in the ambulatory setting.[30]

Table 2. Comparative Overview of Interventional Pulmonology Modalities in Malignant Pleural Effusion[31]

Modality	Primary Indication	Effectiveness	Risks/ Complications	Evidence Gaps
Thoracentesis	Initial diagnosis and short-term symptom relief	Provides rapid dyspnea relief but does not prevent recurrence	Pneumothorax, bleeding, infection; increased risk with repeated procedures	Not durable; repeated thoracentesis is associated with higher procedural burden and complications; guidelines discourage repeated use when definitive options are feasible
Chest tube talc slurry pleurodesis	Definitive pleural intervention in re-expandable lung	Effective in preventing recurrent effusion and reducing the need for repeat procedures	Chest pain, fever, and rare acute respiratory distress syndrome	Optimal patient selection and comparative efficacy versus poudrage remain unclear
Indwelling pleural catheter (IPC)	Long-term outpatient management; trapped lung	Long-term outpatient management; trapped lung	Infection, catheter blockage, tract metastasis, pneumothorax	Optimal timing versus pleurodesis and long-term outcomes require further study; patient-centered selection is emphasized by guidelines[1]
Talc poudrage (VATS-assisted)	Definitive pleurodesis with concurrent thoracoscopy±pleural biopsy	Comparable pleurodesis success to talc slurry	Anesthesia-related risks, postoperative pain, prolonged air leak	Limited evidence in poor performance status patients; no clear superiority over talc slurry in all populations

The approach facilitated fluid removal without bleeding complications, highlighting the feasibility and safety of IPFT as an alternative when options such as an indwelling pleural catheter are unsuitable. Agents, including alteplase and dornase alfa, have been explored, with potential benefits of reducing fluid viscosity and promoting drainage, although their exact role in MPE remains under further study.[30]

INTERVENTIONAL PULMONOLOGY IN PERSISTENT AIR LEAK (PAL)

Persistent air leak (PAL) is defined as the ongoing passage of air from the bronchial tree into the pleural space lasting more than 5–7 days. In critically ill patients, PAL is often complicated by infection or respiratory failure, and surgical repair, the usual standard of care, may not be feasible. In such cases, especially in those requiring mechanical ventilation, tailored minimally invasive approaches are preferred.[32]

A 10-year single-center experience from Asia reported 18 cases of persistent air leak (PAL) among more than 210 patients, with 77.8% showing clinical improvement following endobronchial valve (EBV) therapy.[33] The success of endobronchial valve therapy relies on complete isolation of the target lobe, which requires the absence of collateral ventilation between the treated and adjacent ipsilateral lobes. In the presence of collateral ventilation, airflow may bypass the occluded airway, leading to treatment failure.[34]

Table 3. Bronchoscopic Devices for Persistent Air Leak[35]

Device	Mechanism	Reported Effectiveness	Common Complications	Clinical Use
Endobronchial valve (EBV)	One-way valve allowing air egress while preventing inflow	High success rates reported (≈70–90%)	Migration, infection, and mucus plugging	PAL without collateral ventilation
Endobronchial Watanabe spigot (EWS)	Silicone bronchial occlusion device	Variable success (≈40–85%)	Dislodgement, cough, infection	PAL with or without collateral ventilation

Assessment of collateral ventilation is therefore essential, and the Chartis Diagnostic System (Pulmonx) is commonly used to identify patients most likely to benefit from EBV placement accurately.[34]

Similarly, a multicenter study by Alfonso et al evaluated 74 patients and achieved complete resolution of air leaks in 91%. Using the balloon occlusion method to identify leak sites, EBVs were selectively placed in segmental bronchi, avoiding complete lobar exclusion in post-lobectomy patients to preserve ventilation.[36]

Resolution occurred rapidly, with 68% of patients improving within 24 hours and an additional 32% within 7 days after valve placement. Only 3% of patients failed to respond, while others benefited from adjunctive measures such as autologous blood patch. Importantly, hospital length of stay was significantly reduced after EBV insertion, underscoring its clinical efficacy and cost-effectiveness.[36]

Another option is the Endobronchial Watanabe Spigot (EWS®), a silicone device developed for bronchial occlusion. Early reports demonstrated 80% success, with subsequent studies confirming resolution rates of 29–84% across different patient groups. Although currently approved only in Japan, spigots have been safely used with infrequent complications such as cough, fever, or device dislodgement.[32] Key differences between endobronchial valves and endobronchial Watanabe spigots in the management of persistent air leak are summarized in Table 3.[35]

INTERVENTIONAL PULMONOLOGY IN EMPHYSEMA AND PULMONARY HYPERINFLATION

Pulmonary emphysema, a subtype of COPD, leads to alveolar destruction and reduced lung elasticity, resulting in static and dynamic hyperinflation. This hyperinflation impairs ventilation efficiency and limits physical activity.[37,38] Interventional pulmonology offers minimally invasive lung-volume-reduction techniques—such as endobronchial valve placement and airway bypass—to deflate hyperinflated lung regions, improve respiratory mechanics, and enhance quality of life. These procedures are suitable for selected patients with advanced emphysema who remain symptomatic despite optimal medical therapy. In end-stage cases, lung transplantation remains the definitive option.[39,40]

Management of severe emphysema and pulmonary hyperinflation includes both surgical and bronchoscopic lung volume reduction techniques. Lung volume reduction surgery (LVRS) has been shown to reduce

hyperinflation, improve respiratory mechanics, exercise tolerance, and quality of life.[38,41] However, its benefit is limited in patients with FEV_1 <20%, DLCO <20%, or homogeneous emphysema—populations that also face increased perioperative mortality (up to 15%) and substantial healthcare costs.[41,42]

To minimize surgical risks, bronchoscopic lung volume reduction (BLVR) has emerged as a less invasive alternative.[43,44] This includes techniques such as endobronchial valves (EBV), thermal vapor ablation, airway bypass stents, and targeted lung denervation. EBV, especially the Zephyr valve, is designed to induce lobar atelectasis by permitting unidirectional airflow—allowing trapped air to escape during expiration but preventing re-entry during inspiration. This can lead to improved lung mechanics and patient-reported outcomes in those with heterogeneous emphysema and no collateral ventilation.[44,45]

While promising, BLVR is not without risks. Pneumothorax remains the most common complication, occurring in up to 30% of patients.[44,46] Other adverse events include COPD exacerbations, pneumonia, hemoptysis, and valve migration.[46] The VENT trial and subsequent randomized studies have demonstrated comparable efficacy between LVRS and BLVR in selected patients, with BLVR showing fewer complications and faster recovery times.[47]

In conclusion, both lung volume reduction surgery and bronchoscopic lung volume reduction offer significant benefits in appropriately selected patients; however, accumulating evidence supports bronchoscopic approaches, particularly endobronchial valve–based therapy, as effective and safer alternatives to surgery with increasing adoption in real-world clinical practice. A comparative summary of these approaches is presented in Table 4.[48]

Table 4. Comparison Between LVRS and BLVR[48]

Aspect	LVRS	BLVR (Endobronchial Valve–based)
Approach	Surgical resection of hyperinflated lung tissue	Minimally invasive bronchoscopic placement of one-way valves
Primary Indication	Severe emphysema with suitable anatomy and acceptable surgical risk	Advanced emphysema is symptomatic despite optimal medical therapy
Patient Selection	Best outcomes in upper-lobe predominant emphysema with low exercise capacity	Requires heterogeneous emphysema and absence of collateral ventilation
Effectiveness	Improves lung function, exercise tolerance, and quality of life in selected patients	Comparable improvements in lung function, dyspnea, and quality of life in well-selected patients
Advantages	Durable lung volume reduction in appropriate candidates	Less invasive; shorter hospital stays and faster recovery
Risks/ Complications	High perioperative morbidity; mortality up to 15% in high-risk patients	Pneumothorax, COPD exacerbation, infection, valve migration
Hospital Stay	Prolonged postoperative hospitalization	Typically shorter hospitalization
Evidence Gaps	Limited applicability due to surgical risk; not suitable for many patients	Long-term durability and optimal selection criteria are still evolving.
Comparative Evidence	No clear superiority over BLVR demonstrated in direct comparisons	No clear superiority over LVRS; outcomes are highly dependent on patient selection

The extent of emphysema can be objectively quantified using CT imaging through a scoring method adapted from Goddard and Bergin. Each CT slice is independently evaluated for parenchymal destruction, characterized by low attenuation areas and vascular disruption, and assigned a score reflecting disease severity. Cumulative scores across multiple slices provide an individualized emphysema burden index.[49]

Beyond overall severity, emphysema distribution is assessed using a heterogeneity score calculated from upper- and lower-lobe involvement. A difference greater than 25% indicates heterogeneous emphysema, a phenotype associated with better outcomes following lung volume reduction interventions, including bronchoscopic approaches.[50]

In addition, dynamic airway abnormalities such as tracheobronchomalacia or excessive dynamic airway collapse may coexist in patients with advanced emphysema and influence procedural outcomes. These conditions are diagnosed using dynamic bronchoscopy or expiratory-phase CT imaging and should be considered during interventional planning.[51]

Airway malacia refers to excessive collapse of the airway lumen due to weakness in the cartilaginous structure or posterior wall membrane. It is diagnosed when there is more than 50% narrowing of the airway during expiration. Subtypes include tracheomalacia (TM), bronchomalacia (BM), and tracheobronchomalacia (TBM), depending on the anatomical site involved.

In children, airway malacia can be congenital (Type I), secondary to extrinsic compression (Type II), or acquired from chronic inflammation or iatrogenic causes (Type III). In adults, TM can also be primary—due to congenital structural defects or genetic syndromes—or secondary, following prolonged intubation, chronic inflammation, infections, or mechanical compression from tumors or vascular anomalies.

A related condition, excessive dynamic airway collapse (EDAC), involves posterior membrane invagination during expiration without cartilage involvement and is often associated with COPD and asthma. The EDAC and TBM can present with similar expiratory symptoms and may coexist.[52,53]

Diagnosis is typically established through dynamic bronchoscopy or expiratory-phase CT imaging, which reveal characteristic airway collapse patterns and help differentiate between excessive dynamic airway collapse and tracheobronchomalacia. Beyond diagnosis, interventional pulmonology plays a therapeutic role in selected patients, particularly those with severe symptoms refractory to medical management. Bronchoscopic airway stenting may provide immediate stabilization of the airway lumen and relief of symptoms.[54]

At the same time, procedural findings also help identify patients who may benefit from surgical tracheobronchoplasty or other definitive interventions. Recognizing these dynamic patterns is therefore

essential for both diagnostic and interventional decision-making.[54]

However, the broader adoption of interventional pulmonology is limited by resource availability, operator expertise, and the need for careful patient selection. Cost-effectiveness data remain heterogeneous, particularly across different healthcare systems, highlighting the importance of further studies and equitable access strategies.

CONCLUSION

Interventional pulmonology offers safe, effective, and minimally invasive options for symptom relief in advanced pulmonary diseases, resulting in meaningful improvements in dyspnea, functional capacity, and patient-reported quality of life. By enabling rapid symptom control, reducing procedure-related risks, and shortening hospital stay, these interventions complement standard palliative care across a range of clinical contexts. With appropriate patient selection, multidisciplinary collaboration, and broader accessibility, interventional pulmonology continues to strengthen its role as a key component of palliative respiratory management.

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