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Management of Persistent Air Leak and Bronchopleural Fistula in Acute Respiratory Distress Syndrome: A Systematic Review With Narrative Synthesis

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Abstract

Persistent air leak (PAL) and bronchopleural fistula (BPF) can complicate acute respiratory distress syndrome (ARDS), prolong mechanical ventilation, and delay liberation from extracorporeal membrane oxygenation (ECMO), yet evidence guiding intervention selection is limited. This systematic review with narrative synthesis, conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020, searched four major databases for reports evaluating bronchoscopic interventions or autologous blood pleurodesis for PAL or BPF in mechanically ventilated or ECMO-supported patients. Heterogeneity and the scarcity of comparator arms precluded meta-analysis. The only comparative ARDS-specific study evaluated autologous blood pleurodesis. Evidence for endobronchial valves and related devices consisted mainly of observational cohorts, case series, and case reports, including patients on venovenous ECMO. Successful bronchoscopic therapy depended on accurate localization of the leak, whereas large, multiple, infected, or complex fistulas often required multimodal or surgical management. Certainty of the evidence was low, and no study directly compared blood pleurodesis, endobronchial valves, and surgery. The available low-certainty evidence supports an individualized, physiology-based approach to management; however, comparative evidence is insufficient to establish the superiority of any intervention. Management should minimize fistula flow while ensuring pleural drainage and infection control. Blood pleurodesis or bronchoscopic occlusion may facilitate air-leak resolution and liberation from mechanical ventilation or ECMO in selected patients, whereas surgical management may be required for patients with large, complex, infected, or refractory defects.

Categories: Pulmonology, Internal Medicine
Keywords: acute respiratory distress syndrome, blood pleurodesis, bronchopleural fistula, bronchoscopy, endobronchial valve, extracorporeal membrane oxygenation, persistent air leak

Introduction And Background

Persistent air leak (PAL) describes a pathologic communication between the airway and pleural space that persists beyond the expected period of healing. PAL commonly arises from a bronchopleural or alveolopleural fistula, although the duration used to define persistence varies from 24 hours to five days. Consequently, definitions and terminology remain inconsistent across the literature [1-3]. A bronchopleural fistula (BPF) is defined as a connection between the pleural cavity and a bronchus, whereas an alveolopleural fistula refers to an air leak originating from the lung parenchyma, although the two terms are often used interchangeably [3].

PAL and BPF are uncommon but serious complications of acute respiratory distress syndrome (ARDS). Pneumothorax occurs in approximately 30% of patients with ARDS in historical series, and PAL has been associated with markedly increased mortality [4]. COVID-19 ARDS further highlighted the problem, particularly among patients requiring prolonged mechanical ventilation or venovenous extracorporeal membrane oxygenation (VV-ECMO) [5].

Positive-pressure ventilation can perpetuate a fistula by maintaining the airway-to-pleural pressure gradient. In ECMO-supported patients, an unresolved PAL may prevent lung recruitment and delay liberation from extracorporeal support [5,6]. Mechanically ventilated and ECMO-supported patients therefore warrant separate consideration: positive pressure sustains flow across the defect, the leak can compromise effective ventilation, and critical illness and systemic anticoagulation increase the risk of surgical repair [3,5]. Because many patients are poor surgical candidates owing to critical illness or anticoagulation, clinicians may use bronchoscopic occlusion, including endobronchial valves (EBVs), or pleurodesis-based strategies [3,4,7-9]. EBVs are one-way valves placed bronchoscopically in the segmental or lobar airway supplying the leak; they allow air and secretions to leave the target segment during

expiration while preventing inflow during inspiration, thereby reducing flow across the fistula [7,8]. Autologous blood pleurodesis involves instilling the patient's own blood into the pleural space through the chest tube, where it is thought to seal the leak through clot formation and promote adhesion of the visceral and parietal pleura [4,9].

This review integrates fragmented evidence for PAL/BPF management in critically ill patients receiving invasive mechanical ventilation or ECMO, with particular emphasis on ARDS. It evaluates treatment selection according to fistula physiology, anatomy, localization, pleural apposition, infection, tissue viability, and the feasibility of pleurodesis, bronchoscopic intervention, or surgery. The objective is to define a clinically useful escalation framework without implying that the current evidence can establish the superiority of one intervention.

Review

Methods

We performed this systematic review and narrative synthesis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations [10]. This project was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD420261488308. There were no deviations from the registered protocol.

Data Sources and Search Strategy

PubMed, Embase, Scopus, and Web of Science were searched from database inception through August 8, 2026. Search concepts included respiratory distress syndrome, bronchial fistula, bronchoscopy, and blood patch, combined using database-appropriate Boolean operators. The complete database-specific search strategies are provided in the Appendix.

Study Selection

Records were exported to Rayyan, where duplicates were removed automatically and then verified manually. Two authors (MA and JC) independently screened titles and abstracts, assessed full texts, extracted data, and performed quality assessments. Disagreements were resolved through discussion with a third author (RN). The PRISMA flow diagram (Figure *1*) reports 197 records identified, 41 duplicates removed, 156 records screened, 139 records excluded, 17 reports assessed for eligibility, one non-English report excluded, and 16 reports included [11].

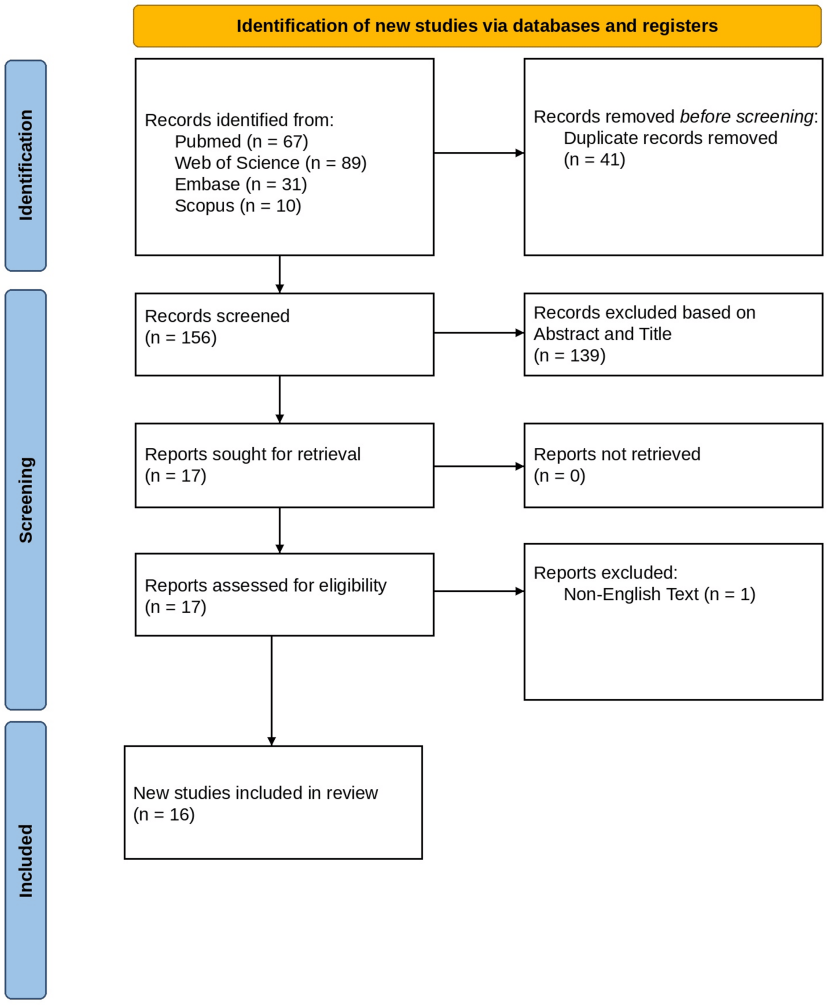


FIGURE 1: PRISMA 2020 flow diagram

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Eligibility Criteria

Eligible study designs included prospective or retrospective studies, randomized or nonrandomized trials, case series, and case reports. Reports had to include mechanically ventilated or ECMO-supported patients with PAL or BPF (or, in a small number of technique-relevant reports, an anatomically related fistula) treated with a bronchoscopic intervention or autologous blood pleurodesis and report at least one prespecified outcome. No restrictions were applied based on publication date, age, or comparator status. Non-English reports, animal or in vitro studies, reports without an eligible intervention or extractable outcome, and letters, commentaries, or editorials without original data were excluded.

Data Extraction

Data were extracted using a standardized extraction form. Extracted variables included first author, year, location, study design, sample size, patient population, ARDS status, mechanical ventilation or ECMO support, fistula context, intervention, comparator, localization method, follow-up, air-leak outcome, time to resolution, ventilator or ECMO weaning, complications, and mortality. Discrepancies in extracted data were resolved by rechecking the source report and, where needed, through discussion with the third author (RN).

Quality Assessment

The Newcastle-Ottawa Scale [12] was used for the single comparative observational study, and the Murad et al. tool [13] was used for case reports and case series. Assessments were completed independently by two

reviewers, with disagreements resolved through discussion. The Murad tool assesses selection, ascertainment, causality, and reporting across eight items; as recommended by its developers, overall risk of bias was judged by consensus according to the number and importance of unmet items rather than by a summary score. The Newcastle-Ottawa Scale rating was based on its selection, comparability, and outcome domains. Appraisal findings informed the narrative synthesis; studies were not excluded solely on the basis of quality.

Outcomes and Synthesis

The primary outcomes were air-leak resolution or a clinically important reduction sufficient to facilitate liberation from mechanical ventilation or ECMO, and procedural complications. Secondary exploratory outcomes were ICU and hospital length of stay, duration of mechanical ventilation or ECMO, and mortality. A meta-analysis was not undertaken because of heterogeneity in study design, etiology, device, outcome definition, and patient selection, together with the near-complete absence of comparator arms.

The narrative synthesis was structured in two steps. First, studies were grouped by intervention: physiologic ventilatory management, autologous blood pleurodesis, EBVs and bronchial occlusion devices, and multimodal or surgical management. Second, outcomes were tabulated and compared descriptively; where findings conflicted, greater weight was given to larger studies, comparative designs, and reports at lower risk of bias. Effect estimates, confidence intervals, and p-values are reported as published, and no new quantitative analyses were performed.

Confidence in the evidence for each clinical question (Table *1*) was rated qualitatively, considering study design, risk of bias, relevance to the ARDS and ECMO population, consistency across reports, and precision. This body-of-evidence rating is distinct from the study-level risk-of-bias ratings in Table *2*.

Clinical question	Available evidence	Confidence
Reduce airway pressures across BPF	Physiologic reviews and case-level evidence	Moderate physiologic; low clinical
Blood pleurodesis in mechanically ventilated ARDS	One prospective matched nonrandomized study, n=54	Low-moderate
EBV for general PAL	Observational cohorts and case series, including n=65 and n=40	Low-moderate
EBV specifically in ARDS	ARDS subgroups, small series, and cases	Low
EBV in ARDS requiring ECMO	One 10-patient series plus several cases	Low but consistent
EBV versus blood pleurodesis	No direct comparison	Insufficient
EBV versus surgery	No controlled comparison	Very low
Optimal timing of EBV	Observational signal only	Very low
Optimal valve duration/removal	Inconsistent observational practice	Very low

TABLE 1: Evidence hierarchy by clinical question

ARDS, acute respiratory distress syndrome; BPF, bronchopleural fistula; EBV, endobronchial valve; ECMO, extracorporeal membrane oxygenation; PAL, persistent air leak

Confidence ratings apply to the body of evidence for each clinical question and are distinct from the study-level risk-of-bias ratings in Table 2. “Moderate physiologic” denotes a strong mechanistic rationale supported by limited clinical outcome data.

Study	Design/N	Population/ARDS	Support	Etiology	Intervention	Localization	Comparator	Air-leak outcome	Weaning	Complications/mortality	Risk of bias
Caplan et al., 2026 [1]	Retrospective cohort abstract/65	Mixed PAL; ARDS 29.2%	Mixed	Mixed	Intrabronchial valves	Bronchoscopy	None	64.6% resolution; mean 10.8 d	NR	No major intraprocedural event; mortality 20%	Murad; study-level rating: moderate

Bansal et al., 2023 [2]	Case series/2	COVID-19 ARDS with bilateral PTX/PAL	MV	COVID-19 ARDS	Pleuroscopy, blockers, pleurodesis, surgery	Pleuroscopy/bronchoscopy	None	Complete resolution in one; >90% reduction in one	One liberated from MV	One later died from COVID-19 complications	Murad; study-level rating: high
Martínez-Escobar et al., 2006 [4]	Matched nonrandomized study/54	ARDS with PTX and PAL	MV	ARDS-related PAL	Blood pleurodesis 50-75 mL	Pleural apposition <2 cm	Drainage/water seal	Seal time 2 vs. 10 d	MV weaning 5 vs. 16 d	Rare fever/recurrence; mortality 3.7% vs. 29.6%	NOS: low risk
Ficial et al., 2023 [5]	Retrospective series/10	COVID-19 ARDS with refractory PAL	VV-ECMO+MV	COVID-19 ARDS	EBV	Bronchoscopy	None	Immediate cessation in 10/10	Facilitated drain removal and ECMO/MV weaning	No periprocedural event; lower volume leak recurred in 4; 80% survived	Murad; study-level rating: moderate
Ghiani et al., 2018 [6]	Case report/1	Severe ARDS with PAL/PTX	VV-ECMO+MV	ARDS	Two EBVs	Bronchoscopic occlusion	None	Immediate major reduction	ECMO weaned 27 days after EBV; later MV liberation	NR	Murad; study-level rating: high
Travaline et al., 2009 [7]	Multicenter retrospective series/40	Heterogeneous PAL; not ARDS-specific	Mixed	Spontaneous, postoperative, iatrogenic	Zephyr EBV; 1-9/patient	Sequential balloon	None	47.5% resolution; 92.5% improved	Median 7.5 d to tube removal; 11 d to discharge	Uncontrolled; heterogeneous	Murad; study-level rating: moderate
Sun et al., 2025 [14]	Retrospective study/45	Heterogeneous airway fistulas	Mixed	Mixed	Blocking agents, stents, valves	Bronchoscopy	Outcome subgroups	Remission 75% <=5 mm; 30.8% 5-10 mm; 17.6% >10 mm	NR	Higher hsCRP and malignancy linked to failure	Murad; study-level rating: low-to-moderate
Liang et al., 2025 [15]	Retrospective series/6	PAL with underlying lung disease	NR	Mostly secondary spontaneous PTX	Spiration EBVs	Bronchoscopy	None	Chest tube removed in all; mean 4.5 d in 5 before discharge	NR	NR	Murad; study-level rating: moderate
Baste et al., 2018 [16]	Case series/2	Complex broncho-esophageal fistulas; one ARDS	ECMO-supported surgery	Post-radiotherapy	Muscle flap+stent	Surgical/bronchoscopic	None	Healing by 3 mo	Bridge through repair	One death (hemorrhagic stroke after 3 months)	Murad; study-level rating: high
Hodges et al., 2015 [17]	Case report/1	Severe pneumonia; BPF	VV-ECMO+MV	Pneumonia	Bedside EBV	Bronchoscopy	None	Marked reduction; repeat positioning	ECMO and MV weaning	Valve displacement; replaced	Murad; study-level rating: high
Criss et al., 2018 [18]	Pediatric case/1	H1N1/MRSA ARDS; multiple BPFs	ECMO+MV	Infection/ARDS	Embolization+multiple EBVs	Bronchography	None	Multiple leaks controlled	ECMO weaning	NR	Murad; study-level rating: high
Gwilt et al., 2025 [19]	Pediatric case abstract/1	ARDS, PE, BPF	VA-ECMO (extubated)	ARDS	EBV then lobectomy	Balloon	None	Leak reduced, not closed	Surgery required	NR	Murad; study-level rating: high
											Murad;

Talon et al., 2021 [20]	Conference case/1	Post-COVID BPF; multiple defects	Prior VV-ECMO	Post-COVID	Spiration EBVs	Sequential balloon	None	Major reduction/cessation	Chest tube removed	Avoided open-window procedures	study-level rating: high
Elswick et al., 2017 [21]	Case report/1	Post-bilobectomy BPF/empyema	NR	Surgery+chemoradiation	Vascularized flap+EBV	Endobronchial guidance	None	Closure; no recurrence ~12 mo	NR	NR	Murad; study-level rating: high
Wadiwala et al., 2023 [22]	Case report/1	Post-transplant BPF	NR	Lung transplant	Sealant+EBV	Robotic bronchoscopy	None	Resolution; no symptoms ~1 yr	NR	NR	Murad; study-level rating: high
Vakil et al., 2018 [23]	Case report/1	Bronchocutaneous fistula without PTX	NR	Surgery/radiotherapy	Segmental EBVs	Methylene blue	None	Fistula controlled	NR	NR	Murad; study-level rating: high

TABLE 2: Characteristics of primary clinical studies and reports

ARDS, acute respiratory distress syndrome; BPF, bronchopleural fistula; EBV, endobronchial valve; ECMO, extracorporeal membrane oxygenation; H1N1, influenza A subtype H1N1; hsCRP, high-sensitivity C-reactive protein; MRSA, methicillin-resistant Staphylococcus aureus; MV, mechanical ventilation; NOS, Newcastle-Ottawa Scale; NR, not reported; PAL, persistent air leak; PE, pulmonary embolism; PTX, pneumothorax; VA-ECMO, venoarterial extracorporeal membrane oxygenation; VV-ECMO, venovenous extracorporeal membrane oxygenation

Results

Study Characteristics

Sixteen primary clinical reports met the eligibility criteria (Table 2). The evidence comprised one prospective nonrandomized matched case-control study (n=54), one retrospective single-center cohort reported as a conference abstract (n=65), one multicenter retrospective uncontrolled case series (n=40), one retrospective study of heterogeneous airway fistulas (n=45), one single-center case series in ECMO-supported ARDS (n=10), additional small case series, and eight single-patient reports, including two pediatric patients [1,2,4-7,14-23]. Four narrative reviews (Table 3) informed the physiologic and clinical framework but were not treated as primary outcome evidence [3,8,9,24].

Study	Type	Subject	Contribution to synthesis
Grotberg et al., 2021 [3]	Concise review	BPF during mechanical ventilation	Provided the physiologic framework for reducing fistula flow and discussed ECMO, lung isolation, and bronchoscopic therapy
Giddings et al., 2014 [8]	Narrative review	EBVs for BPF/PAL	Summarized early EBV literature and emphasized the absence of controlled trials
Manley et al., 2012 [9]	Narrative review	Autologous blood-patch pleurodesis	Described blood pleurodesis as inexpensive, simple, and generally well tolerated; emphasized limited randomized evidence
Aliaga et al., 2022 [24]	Narrative review	Overall BPF management	Situated valves, stents, and sealants within an escalation pathway for patients who are poor surgical candidates

TABLE 3: Narrative reviews informing the physiologic management framework

BPF, bronchopleural fistula; EBV, endobronchial valve; ECMO, extracorporeal membrane oxygenation; PAL, persistent air leak

The comparative study was rated as having a low risk of bias using the Newcastle-Ottawa Scale. Among the 15 case reports and case series appraised with the Murad tool, one was rated as having a low-to-moderate risk of bias, four a moderate risk of bias, and ten a high risk of bias. Study-level appraisal details are included in Table 2.

Physiologic Management

Across reviews and primary reports, management aimed to reduce airflow across the fistula by lowering tidal volume and peak inspiratory pressure, decreasing positive end-expiratory pressure when feasible, shortening inspiratory time, reducing respiratory rate, avoiding unnecessary chest-tube suction, maintaining adequate pleural drainage, and treating infection or empyema [3]. These measures were supported primarily by physiologic reasoning and case-level evidence rather than randomized comparisons.

Autologous Blood Pleurodesis

The sole controlled comparison was a prospective, nonrandomized matched study of 54 mechanically ventilated patients with ARDS, pneumothorax, and PAL [4]. Autologous blood pleurodesis (50-75 mL; n=27) was compared with conventional chest drainage and water seal (n=27) in patients with visceral-parietal pleural apposition of less than 2 cm. In this small, prospective, nonrandomized matched study, autologous blood pleurodesis was associated with shorter air-leak or chest-tube seal time (2 versus 10 days), ventilator-weaning time (5 versus 16 days), and ICU stay (16 versus 29 days), as well as a lower observed tracheostomy rate. These findings should be interpreted cautiously because of the nonrandomized design and potential confounding. The reported mortality difference cannot establish causality because the study was small, nonrandomized, single-center, conducted under older ARDS and ventilation practices, and limited to patients with favorable pleural apposition.

Endobronchial Valves and Bronchial Occlusion Devices

Twelve reports evaluated EBVs or related bronchial occlusion devices [1,5-7,14,15,17-20,22,23]. The largest cohort was a conference abstract involving 65 patients with mixed PAL etiologies, of whom 29.2% had ARDS [1]. PAL resolved in 64.6% of patients at a mean of 10.8 days after valve placement; in-hospital mortality was 20%, and no intraprocedural complications or massive hemoptysis were reported. Each additional 10 days of PAL before valve placement was associated with an 8% lower probability of resolution, but this association was not statistically significant (p=0.077) and should be regarded as hypothesis-generating. ARDS-specific outcomes were not reported separately in this cohort.

A multicenter series of 40 patients with heterogeneous, non-ARDS PAL reported resolution in 47.5% and improvement in 92.5% after EBV placement [7]. A series of six patients with underlying lung disease, including two with post-ARDS fibrosis, reported chest tube removal in all patients, five before discharge [15].

Evidence in Extracorporeal Membrane Oxygenation-Supported Acute Respiratory Distress Syndrome

In a retrospective series of 152 patients with COVID-19 ARDS treated with VV-ECMO, 10 developed refractory PAL requiring EBV placement [5]. The air leak ceased immediately in all 10 patients after valve placement, although a smaller leak later recurred in four, permitting lung recruitment, pleural drain removal, and progression toward ECMO or ventilator weaning; eight survived to discharge. Smaller reports described reductions in air leak and subsequent ECMO liberation after EBV placement, including a pediatric patient who required bronchography-guided localization and combined embolization because conventional balloon localization was inadequate for multiple fistulas [6,17,18]. One pediatric case on VA-ECMO showed only partial improvement after EBV placement and ultimately required lobectomy, demonstrating that bronchoscopic therapy may fail [19].

Localization, Fistula Size, and Infection

Sequential balloon occlusion was the most frequently described localization method. Alternative approaches included computed tomography, bronchography, the Chartis system, methylene blue instillation, robotic bronchoscopy, and pleuroscopy [18,22,23]. The 45-patient study by Sun et al. reported remission rates of 75% for fistulas 5 mm or smaller, 30.8% for fistulas 5-10 mm, and 17.6% for fistulas larger than 10 mm; higher inflammatory activity and malignant etiology were associated with treatment failure [14]. These findings were observational and may not apply directly to ARDS-related fistulas.

Multimodal and Surgical Management

Large, multiple, infected, or anatomically complex fistulas were treated with combinations of pleuroscopy, customized bronchial blockers, sealants, EBVs, embolization, vascularized tissue flaps, surgical stapling, resection, or ECMO-supported repair [2,16,18,21,22]. These reports demonstrate the feasibility of individualized hybrid treatment but do not permit conclusions about comparative effectiveness. Surgical management was required in selected reports involving major tissue disruption, infection or necrosis, unsuitable anatomy, or PAL despite bronchoscopic treatment [19].

Confidence of Evidence

Only one controlled comparison was identified among the 16 primary reports, and no study directly compared EBV placement with autologous blood pleurodesis or surgery. Confidence ranged from low to moderate for blood pleurodesis and EBV use in general PAL, to insufficient or very low for direct comparisons, timing, and valve removal (Table *1*).

Discussion

This review found that the available evidence supports an individualized approach to PAL/BPF in mechanically ventilated or ECMO-supported patients but does not establish the superiority of any treatment. Fistula flow, pleural apposition, anatomy, infection, tissue viability, and procedural tolerance should guide escalation.

Physiology-Based Escalation Framework

Initial management should ensure adequate pleural drainage, control infection, and reduce the airway-to-pleural pressure gradient [3]. Autologous blood pleurodesis may be considered when the pleural surfaces are adequately apposed; it has the only direct comparative evidence in mechanically ventilated patients with ARDS, although the evidence remains nonrandomized and dated [4]. For a localized segmental or lobar source, balloon occlusion followed by placement of an endobronchial valve or another bronchial occlusion device may be considered in selected patients who are poor surgical candidates, recognizing that the supporting evidence is predominantly observational [1,5-7,14,15,17-20,22,23]. If localization is difficult or the defect is multiple, infected, necrotic, or large, multimodal bronchoscopic and surgical strategies may be required [2,16,18,19,21,22] (Figure *2*).

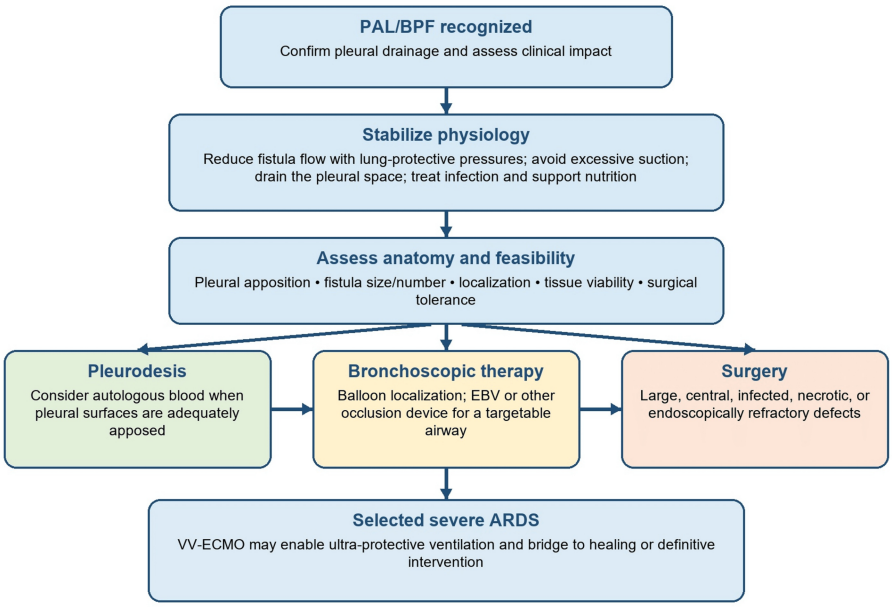


FIGURE 2: Physiology-based clinical management algorithm synthesized from the included evidence

ARDS, acute respiratory distress syndrome; BPF, bronchopleural fistula; EBV, endobronchial valve; PAL, persistent air leak; VV-ECMO, venovenous extracorporeal membrane oxygenation

Image created by the authors using Microsoft PowerPoint, Microsoft Corporation, Redmond, WA, USA.

ECMO should be viewed as an enabling or bridging strategy rather than direct fistula therapy. By permitting very low airway pressures and supporting gas exchange during bronchoscopy or surgery, ECMO may facilitate lung rest, recruitment, and definitive intervention in selected patients with severe ARDS [5,6,16-19].

Comparison With Existing Literature and Contribution

The findings align with prior reviews that emphasize reducing the fistula pressure gradient and describe blood pleurodesis or bronchoscopic occlusion as options for selected patients [3,8,9,24]. The present review provides a focused synthesis of published reports involving mechanically ventilated and ECMO-supported patients, including ECMO-specific cases. However, the small number of studies and the predominance of

case reports and case series limit the strength and generalizability of the conclusions. Its principal contribution is therefore an integrated, physiology-based selection framework rather than a comparative ranking of interventions.

Clinical and Research Implications

For clinicians, the framework offers a structured sequence of options rather than a fixed protocol: optimize ventilation and drainage first, then choose among pleurodesis, bronchoscopic occlusion, and surgery according to pleural apposition, leak localization, and defect characteristics. For researchers, priorities include prospective multicenter registries using standardized definitions of PAL and resolution, reporting of ARDS-specific subgroups, and comparative studies of blood pleurodesis versus EBV, EBV timing, and valve-removal strategies.

Strengths and Limitations

Strengths include a four-database search, independent screening and data extraction by two reviewers, design-appropriate quality appraisal, explicit separation of primary clinical reports from narrative reviews, and synthesis of a clinically important but fragmented evidence base. The review also integrates ARDS- and ECMO-specific evidence with fistula anatomy and treatment feasibility.

Several limitations constrain inference. Only one controlled study was identified; most evidence came from case reports, case series, and conference abstracts. Clinical heterogeneity was substantial, including ARDS and non-ARDS populations, adults and pediatric patients, different fistula etiologies, and changes in definitions and ventilation practices over a long publication period. The English-language restriction may have introduced selection bias. Publication bias is likely because successful procedures are more likely to be reported. Meta-analysis was not feasible, and there were no direct comparisons among EBV, blood pleurodesis, and surgery. The broader mechanically ventilated/ECMO eligibility improves technique-related coverage but limits ARDS-specific certainty. Because all search strategies required an ARDS-related term, reports involving mechanically ventilated or ECMO-supported patients without ARDS may have been incompletely captured.

Conclusions

Current evidence supports considering a physiology-based, individualized escalation strategy for PAL and BPF in mechanically ventilated and ECMO-supported patients, including those with ARDS. However, the available evidence is insufficient to determine the comparative effectiveness of the available interventions. Initial management should reduce fistula flow while ensuring adequate pleural drainage and infection control. In the single comparative ARDS study, autologous blood pleurodesis was associated with shorter air-leak duration, ventilator-weaning time, and ICU stay, as well as lower observed mortality, than conventional drainage; however, a causal benefit cannot be established. EBV and related bronchoscopic techniques may provide minimally invasive options in carefully selected patients, including some receiving VV-ECMO, although the evidence remains predominantly observational. Surgical management may be required for selected patients with large, complex, infected, necrotic, or endoscopically refractory fistulas, depending on anatomy, clinical stability, and the feasibility of alternative interventions. Prospective comparative studies are needed to define optimal treatment selection and timing.

Appendices

Database	Date searched	Records	Search strategy
PubMed	August 8, 2026	67	(Respiratory Distress Syndrome OR ARDS OR acute respiratory distress syndrome OR adult respiratory distress syndrome OR acute lung injury OR ALI) AND (Bronchial Fistula OR bronchopleural fistula OR broncho-pleural fistula OR BPF OR bronchopleural fistulae OR persistent air leak OR prolonged air leak OR alveolar-pleural fistula) AND (Bronchoscopy OR bronchoscop* OR endobronchial OR bronchoscopic intervention OR interventional bronchoscopy OR endobronchial valve OR endobronchial valves OR one-way valve OR unidirectional valve OR Zephyr valve OR Spiration valve OR EBV OR IBV OR blood patch OR autologous blood patch OR blood patch pleurodesis OR autologous blood pleurodesis OR fibrin OR glue OR sealant* OR endobronchial occlusion OR bronchial occlusion OR stent* OR spigot* OR Watanabe spigot OR coil*)
Web of Science	August 8, 2026	89	((ALL=((Respiratory Distress Syndrome OR ARDS OR acute respiratory distress syndrome OR adult respiratory distress syndrome OR acute lung injury OR ALI))) AND ALL=((Bronchial Fistula OR bronchopleural fistula OR broncho-pleural fistula OR BPF OR bronchopleural fistulae OR persistent air leak OR prolonged air leak OR alveolar-pleural fistula))) AND ALL=((Bronchoscopy OR bronchoscop* OR endobronchial OR bronchoscopic intervention OR interventional bronchoscopy OR endobronchial valve OR endobronchial valves OR one-way valve OR unidirectional valve OR Zephyr valve OR speration valve OR EBV OR IBV OR blood patch OR autologous blood patch OR blood patch pleurodesis OR autologous blood pleurodesis OR fibrin OR glue OR sealant* OR endobronchial occlusion OR bronchial occlusion OR stent* OR spigot* OR Watanabe spigot OR coil*))
Embase	August 8, 2026	31	(('ards'/exp OR 'ards' OR 'acute respiration distress syndrome'/exp OR 'acute respiration distress syndrome' OR 'acute respiratory disease syndrome'/exp OR 'acute respiratory disease syndrome' OR 'acute respiratory distress syndrome'/exp OR 'acute respiratory distress syndrome' OR 'adult respiration distress'/exp OR 'adult respiration distress' OR 'adult respiration distress syndrome'/exp OR 'adult respiration distress syndrome' OR 'adult respiratory distress'/exp OR 'adult respiratory distress' OR 'adult respiratory distress syndrome'/exp OR 'adult respiratory distress syndrome' OR 'lung shock'/exp OR 'lung shock' OR 'posttraumatic lung failure'/exp OR 'posttraumatic lung failure' OR 'posttraumatic pulmonary insufficiency'/exp OR 'posttraumatic pulmonary insufficiency' OR 'respiratory distress syndrome, acute'/exp OR 'respiratory distress syndrome, acute' OR 'respiratory distress syndrome, adult'/exp OR 'respiratory distress syndrome, adult' OR 'respiratory distress, adult'/exp OR 'respiratory distress, adult' OR 'shock lung'/exp OR 'shock lung') AND ('broncho pleural fistula'/exp OR 'broncho pleural fistula' OR 'bronchopleural fistula'/exp OR 'bronchopleural fistula') OR 'bronchial fistula'/exp OR 'bronchial fistula' OR 'bronchus fistula'/exp OR 'bronchus fistula') AND ('bronchial endoscopy'/exp OR 'bronchial endoscopy' OR 'bronchoscopy'/exp OR 'bronchoscopy' OR 'laryngotracheobronchoscopy'/exp OR 'laryngotracheobronchoscopy' OR 'tracheobronchoscopy'/exp OR 'tracheobronchoscopy') AND ('spiration'/exp OR 'spiration' OR 'spiration (endobronchial valve)'/exp OR 'spiration (endobronchial valve)' OR 'spiration valve'/exp OR 'spiration valve' OR 'zephyr (endobronchial valve)'/exp OR 'zephyr (endobronchial valve)' OR 'airway sizing kit'/exp OR 'airway sizing kit' OR 'endobronchial airway sizing kit'/exp OR 'endobronchial airway sizing kit' OR 'endobronchial one-way valve'/exp OR 'endobronchial one-way valve' OR 'endobronchial valve'/exp OR 'endobronchial valve')
Scopus	August 8, 2026	10	TITLE-ABS-KEY (("acute respiratory distress syndrome" OR ards OR "acute lung injury")) AND TITLE-ABS-KEY (("bronchopleural fistula*" OR "broncho-pleural fistula*" OR bpf OR "alveolopleural fistula*" OR "alveolo-pleural fistula*")) AND TITLE-ABS-KEY ((bronchoscop* OR endobronchial OR "endobronchial valve*" OR ebv OR "blood patch*" OR "pleural blood patch*" OR "autologous blood patch")) AND TITLE-ABS-KEY ((safe* OR efficacy OR outcome* OR success* OR complication* OR surviv* OR mortalit*))
Total		197	

TABLE 4: Literature search strategy and results across databases

All databases were searched from inception to August 8, 2026, with no language, date, or study-design limits applied at the search stage. Duplicates (n=41) were removed in Rayyan before screening.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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