

**MULTIDISCIPLINARY MANAGEMENT OF COMPLEX TRACHEAL STENOSIS:
INTEGRATION BETWEEN THORACIC SURGERY AND INTERVENTIONAL**

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Abstract

Acquired tracheal stenosis represents a significant complication, primarily associated with prolonged orotracheal intubation, mechanical ventilation, and tracheostomy. Between 2021 and 2026, recent

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literature highlighted substantial advances in the understanding of risk factors, early diagnosis, and therapeutic strategies. Early recognition in critically ill patients, particularly those subjected to prolonged ventilation, and the implementation of preventive protocols in intensive care settings, have been emphasized. Therapeutically, endoscopic approaches, including dilation and stent placement, have demonstrated efficacy in selected cases, especially for short and non-complex stenoses. However, tracheal resection with reconstruction remains the gold standard for extensive or refractory lesions. Comparative analyses indicate that optimal outcomes are achieved through careful patient selection and integration of specialized teams. The multidisciplinary model, involving interventional pulmonology, thoracic surgery, anesthesiology, and intensive care, is central to optimizing results and reducing complications. Structured longitudinal follow-up is essential for monitoring recurrence and ensuring long-term functional stability. Future perspectives emphasize increased incorporation of technologies such as computational modeling and customized devices, consolidating precision medicine in airway management. Contemporary management of tracheal stenosis should therefore be integrated, individualized, and evidence-based, prioritizing patient safety and functional outcomes.

Keywords: Bronchoscopy, Mechanical ventilation, Multidisciplinary approach, Tracheal resection, Tracheal stenosis.

INTRODUCTION

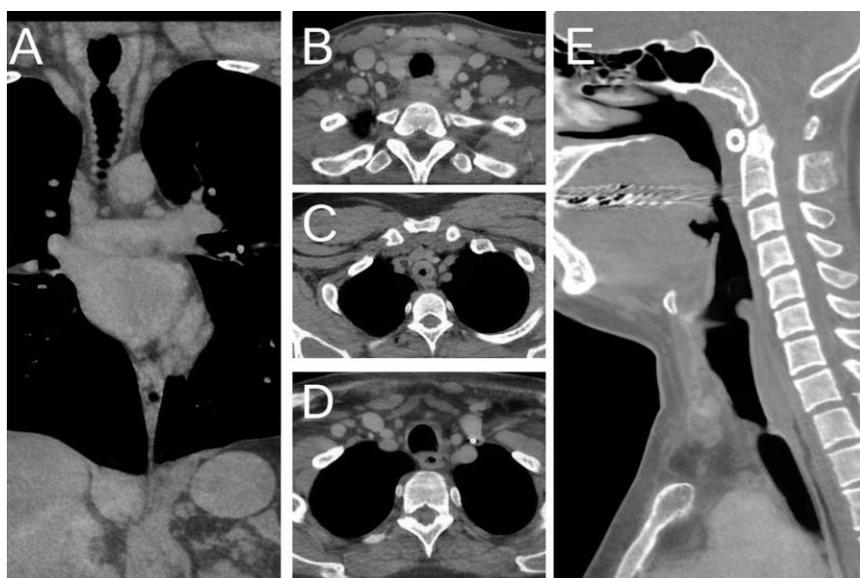
Complex tracheal stenosis constitutes a challenging clinical condition, characterized by a significant reduction in the tracheal lumen associated with extensive structural alterations, relevant functional impairment, and, frequently, multiple comorbidities. It is a potentially severe pathology, capable of progressing with progressive dyspnea, stridor, respiratory failure, and substantial impact on quality of life. In recent years, the increase in prolonged mechanical ventilation—especially in the context of the COVID-19 pandemic—has contributed to a higher incidence of post-intubation and post-

tracheostomy stenoses, reinforcing the need for integrated, evidence-based therapeutic strategies (Ayten et al., 2022; Brascia et al., 2023).

Figure 1 presents a computed tomography image showing significant narrowing of the tracheal lumen, with circumferential reduction and parietal thickening compatible with complex stenosis.

Figure 1

Computed tomography showing complex tracheal stenosis with significant lumen reduction and parietal thickening.



Source: Post Intubation Tracheal Stenosis (2021)

Acquired tracheal stenosis—especially of post-intubation etiology—remains the most prevalent cause in specialized services. The pathophysiological process involves tracheal mucosal ischemia induced by cuff pressure, local inflammation, cartilaginous necrosis, and subsequent formation of scar tissue, resulting in progressive lumen narrowing (Wang; Tian, 2022; Wang; Fan, 2023). Systematic reviews identify risk factors such as prolonged mechanical ventilation time, high cuff pressure, local infection, repeated re-intubations, and critical clinical conditions (Hong et al., 2024).

In patients undergoing prolonged ventilation, the prevalence of tracheal stenosis can be significant, requiring systematic clinical and bronchoscopic surveillance (Ghiani et al., 2022).

In the post–COVID-19 scenario, an even more complex clinical profile is observed, with extensive inflammatory lesions of the upper airways, greater tissue fragility, and association with tracheomalacia and dynamic collapse (Brascia et al., 2023). These elements complicate management and increase the need for a multidisciplinary approach. Furthermore, associated conditions—such as retrosternal goiter and compressive thyroid pathologies—may coexist with or contribute to tracheal narrowing, requiring meticulous surgical planning (Zuo et al., 2022; Boyko et al., 2025).

The complexity of tracheal stenosis is not limited to the anatomical extent of the lesion; it also involves factors such as the length of the affected segment, presence of active inflammation, cartilaginous involvement, recurrence after prior interventions, and coexistence of tracheoesophageal or bronchoesophageal fistulas (Alhadid et al., 2025). In such cases, the therapeutic decision must consider not only the technical feasibility of tracheal resection, but also the patient’s overall clinical condition, respiratory stability, and available resources.

Traditionally, tracheal resection with end-to-end anastomosis is considered the definitive treatment for selected benign stenoses, with good outcomes when performed in specialized centers (Dhaha et al., 2022; Boyko et al., 2025). However, not all patients are immediate candidates for surgery. Extensive lesions, active inflammation, clinical instability, or high anesthetic risk may require intermediate or alternative therapies, consolidating the role of interventional pulmonology in contemporary management (Ravikumar et al., 2023).

Interventional pulmonology has significantly expanded its scope in recent decades, incorporating advanced techniques of therapeutic bronchoscopy, balloon dilation, mechanical resection, electrocautery, laser, cryotherapy, and implantation of tracheal prostheses (Gesthalter; Channick, 2023). The rational use of stents in benign central airway obstructions is guided by international guidelines, which emphasize careful case selection, rigorous follow-up, and multidisciplinary evaluation (World Association for Bronchology and Interventional Pulmonology, 2024).

Bronchoscopy, in addition to being a fundamental diagnostic tool, plays a central role in the integrated therapeutic strategy. It enables precise characterization of the lesion, dynamic assessment of collapse, measurement of stenosis length and severity, and minimally invasive interventions that can stabilize the patient or serve as a bridge to definitive surgery (Ravikumar et al., 2023; Yang et al., 2024). In case series involving endoscopic treatment of post-intubation stenoses, promising results are observed, especially when structured follow-up and appropriate patient selection are present (Salloum et al., 2021).

Technological advances have also increased diagnostic and therapeutic precision. The incorporation of endobronchial ultrasound and other imaging techniques contributes to more accurate assessment of the tracheal wall and adjacent structures (Nathani et al., 2024). Computational fluid dynamics studies applied to the airway offer innovative perspectives for individualized surgical planning, allowing simulation of respiratory flows and prediction of post-intervention outcomes (Kara et al., 2025).

In cases of extremely severe stenosis or during complex surgical procedures, advanced respiratory support strategies become essential. The use of veno-venous extracorporeal membrane oxygenation (ECMO) has been described as a viable resource both in complex tracheobronchial resections and in high-risk bronchoscopic therapies, providing hemodynamic and ventilatory safety during intervention (Voltolini et al., 2024; Zhou et al., 2025). Integration among the surgical team, anesthesiology, and interventional pulmonology is decisive in these scenarios.

Anesthetic management represents another critical component in the multidisciplinary approach. In patients with severe stenosis, techniques such as awake fiberoptic intubation may be essential to ensure a secure airway before anesthetic induction (Sierra; Székessy, 2025). In addition, coordination between the thoracic surgeon and the interventional pulmonologist enables prior planning of airway access, definition of ventilation strategies, and contingency planning for intraoperative events (Boyko et al., 2025).

It is important to emphasize that not every stenosis should be approached exclusively from a surgical perspective or exclusively endoscopically. Contemporary literature reinforces that the best strategy often results from sequential or complementary combination of both modalities, respecting the individual characteristics of the patient and the lesion (Souha et al., 2023). In selected cases, customized solutions such as custom T-tubes have been described as an effective alternative in complex stenoses, expanding the available therapeutic arsenal (Ayasa et al., 2025).

In this context, the concept of multidisciplinary management transcends the mere simultaneous involvement of different specialties. It entails structured integration among thoracic surgery, interventional pulmonology, anesthesiology, intensive care, radiology, and, when necessary, head and neck surgery and endocrinology. This articulation favors shared decisions, definition of care pathways, and individualization of the therapeutic plan, with potential positive impact on morbidity and mortality and recurrence rates (Ravikumar et al., 2023; Gesthalter; Channick, 2023).

Additionally, early recognition of tracheal stenosis and appropriate severity stratification fundamental to avoid delayed interventions and irreversible complications. Systematic evaluation of risk factors—especially in patients subjected to prolonged mechanical ventilation—should be integrated into institutional follow-up protocols (Hong et al., 2024; Ghiani et al., 2022). Timely treatment, based on an integrated approach, can reduce the need for repeated procedures and improve functional outcomes.

Given this panorama, complex tracheal stenosis imposes challenges that require overcoming fragmented care models. Integration between thoracic surgery and interventional pulmonology emerges as a central axis in constructing safe, effective, and personalized therapeutic strategies. The articulation between minimally invasive endoscopic techniques, definitive surgical interventions, and advanced life support expands management possibilities and favors better clinical results.

Thus, understanding the clinical, anatomical, and technical foundations that support the multidisciplinary management of complex tracheal stenosis is essential to improve clinical practice and consolidate collaborative models of care. Effective integration between thoracic surgery and

interventional pulmonology not only optimizes therapeutic decisions, but also redefines the treatment paradigm for this condition, aligning with the most recent scientific evidence and the growing demands of contemporary clinical practice.

METODOLOGY

This is an integrative literature review, with a qualitative approach and descriptive-analytical character, whose objective was to analyze scientific evidence published between 2021 and 2026 regarding the multidisciplinary management of complex tracheal stenosis, with emphasis on integration between thoracic surgery and interventional pulmonology.

The integrative review was chosen because it enables the synthesis of different methodological designs (observational studies, case series, systematic reviews, guidelines, and clinical reports), allowing a broader understanding of contemporary therapeutic strategies applied to complex tracheal stenosis. The methodological process followed the classic stages: identification of the problem, definition of the guiding question, literature search, application of eligibility criteria, data extraction and categorization, critical analysis, and synthesis of results.

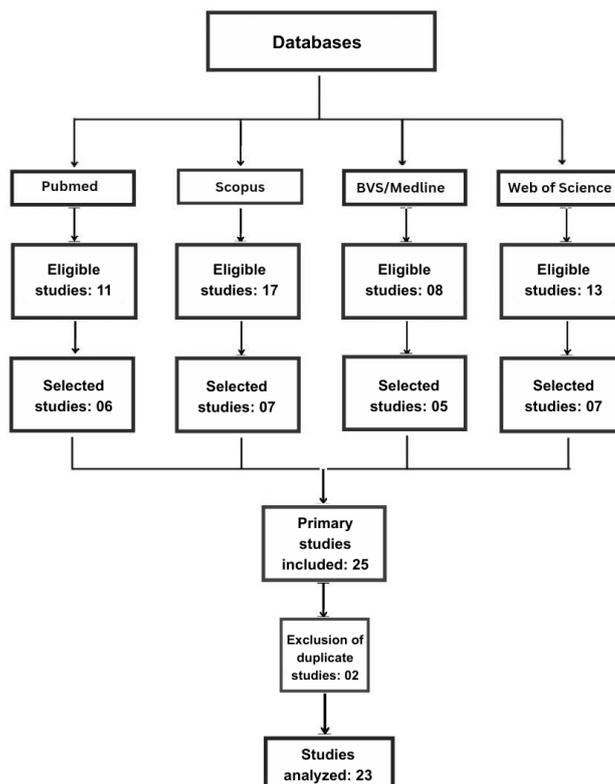
The guiding question was structured based on the PICO strategy adapted for an integrative review: P (patients with complex tracheal stenosis), I (integrated surgical and endoscopic interventions), C (isolated management or conventional strategies), and O (clinical and functional outcomes and complications). Thus, the following question was formulated: What is the recent scientific evidence on the effectiveness and outcomes of multidisciplinary management of complex tracheal stenosis involving thoracic surgery and interventional pulmonology?

The bibliographic search was conducted in the PubMed/MEDLINE, Scopus, Web of Science, Embase, and Virtual Health Library (BVS) databases, considering publications in English, Portuguese, and Spanish. Controlled descriptors (MeSH and DeCS) and free terms combined with Boolean operators AND and OR were used, such as: “tracheal stenosis”, “complex tracheal stenosis”, “post-intubation

tracheal stenosis”, “interventional pulmonology”, “thoracic surgery”, “airway stenting”, “bronchoscopy”, “ECMO”, “multidisciplinary approach”, and “tracheal resection”. The search strategy was adapted to the specificities of each database.

Figure 1

Flowchart of the identification and screening process



Source: Authors

Inclusion criteria comprised: (1) articles published between 2021 and 2026; (2) original studies, systematic reviews, clinical guidelines, and clinically relevant case reports; (3) research addressing acquired or complex tracheal stenosis; (4) studies describing surgical interventions, bronchoscopic interventions, or a combined approach; (5) full-text availability.

Excluded were: (1) experimental studies exclusively in animal models; (2) duplicate publications; (3) articles focusing exclusively on malignant stenoses without an integrated therapeutic approach; (4) editorials and letters to the editor without relevant clinical data.

The selection process occurred in three stages: title reading, abstract analysis, and full-text assessment. Screening was performed independently by two reviewers, with disagreements resolved by consensus. Extracted data included: author and year of publication, country of origin, study design, number of patients, stenosis etiology, type of intervention (endoscopic, surgical, or combined), use of advanced support (such as ECMO), complications, and main clinical outcomes.

Data analysis was performed through thematic categorization, organizing findings into four main axes: (1) epidemiology and risk factors; (2) endoscopic strategies in interventional pulmonology; (3) surgical approach and tracheal resection; (4) multidisciplinary integration and advanced intraoperative support. The synthesis was conducted narratively, highlighting convergences, divergences, and knowledge gaps.

Because this is a literature review using exclusively publicly available secondary data, submission to a Research Ethics Committee was not required, according to current national and international ethical guidelines.

RESULTS AND DISCUSSION

Analysis of studies published between 2021 and 2026 showed significant progress in understanding complex tracheal stenosis, particularly with regard to integration between thoracic surgery and interventional pulmonology. There was a predominance of acquired post-intubation and post-tracheostomy stenoses. The analyzed publications converge on the need for an individualized approach based on the anatomical extent of the lesion, the patient's clinical condition, the presence of comorbidities, and available institutional resources. Overall, results indicate that isolated strategies tend to present higher recurrence rates or complications when compared to integrated care models, reinforcing the role of multidisciplinary management in optimizing clinical outcomes.

COMPLEX TRACHEAL STENOSIS AND ITS IMPACT ON THERAPEUTIC DECISION-MAKING

Complex tracheal stenosis represents a clinical condition of high severity, whose therapeutic approach requires meticulous evaluation of the anatomical, pathophysiological, and clinical determinants involved. Unlike simple stenoses—characterized by short segment involvement and no significant cartilaginous compromise—complex forms involve extensive segments, structural deformity of the tracheal wall, persistent inflammation, dynamic collapse, and, at times, associated comorbidities that increase perioperative risk. In this context, therapeutic decision-making cannot be standardized; it must be individualized and grounded in objective criteria and recent scientific evidence.

Post-intubation etiology remains the principal cause of acquired tracheal stenosis. As highlighted by Wang and Tian (2022), the pathophysiological mechanism is related to tracheal mucosal ischemia induced by excessive pressure from the cuff of the orotracheal tube, followed by necrosis, inflammation, and formation of fibrous scar tissue. Complementarily, Wang and Fan (2023) emphasize that post-intubation stenosis remains underdiagnosed in many services despite its clinical relevance, especially in patients subjected to prolonged mechanical ventilation. Lesion severity, intubation duration, and the presence of local infection directly influence the anatomical pattern of stenosis, impacting therapeutic choice.

Classifying stenosis as “complex” implies considering not only the degree of luminal obstruction, but also the length of the affected segment, tracheal cartilage involvement, and the presence of tracheomalacia. Souha et al. (2023) underscore that bronchoscopic evaluation associated with computed tomography is fundamental for precise characterization of the lesion, allowing distinction between predominantly inflammatory stenoses—potentially reversible with endoscopic therapies—and rigid cicatricial stenoses, which often require definitive surgical intervention.

The presence of dynamic airway collapse is a decisive factor in therapeutic definition. Yang et al. (2024) demonstrate that collapse associated with post-intubation stenosis reduces the effectiveness of isolated bronchoscopic therapies, increasing the probability of symptomatic recurrence. In such cases,

simple endoscopic dilation may provide transient relief without modifying the structural substrate of the disease. Thus, early identification of tracheomalacia or tracheal wall instability should guide more comprehensive strategies, including segmental resection or judicious use of prostheses.

Guidelines from the World Association for Bronchology and Interventional Pulmonology (2024) reinforce that stent implantation in benign stenoses must be carefully indicated, considering the risk of granulation tissue formation, migration, and infection. Although a stent may represent a viable alternative in inoperable patients or as a temporary measure, indiscriminate use can complicate future surgical interventions. Therefore, therapeutic decision-making must weigh the balance between immediate symptomatic benefit and long-term impact.

With respect to surgical treatment, tracheal resection with end-to-end anastomosis remains the gold standard for complex cicatricial stenoses, provided that adequate clinical conditions exist. Dhaha et al. (2022), when analyzing patients undergoing resection for post-intubation stenosis, observed good functional outcomes and a low recurrence rate when the procedure was performed in a specialized setting. However, the authors stress that surgical success depends on careful case selection, adequate tracheal mobilization, and rigorous postoperative control.

In addition to factors intrinsic to stenosis, extrinsic conditions also influence therapeutic decision-making. Zuo et al. (2022), in a study involving patients with retrosternal goiter associated with tracheal stenosis, demonstrated that extrinsic compression modifies surgical planning and may require a combined approach with endocrine surgery. In these cases, integration among specialties becomes indispensable to reduce risks and optimize results.

In situations of critical stenosis with imminent risk of respiratory failure, management complexity increases significantly. Voltolini et al. (2024) describe the use of veno-venous extracorporeal membrane oxygenation (ECMO) as a support strategy during complex tracheobronchial resections, enabling safe ventilatory control in patients with severe obstruction. Similarly, Zhou et al. (2025) report the use of ECMO support in high-risk bronchoscopic therapies, enhancing safety for minimally invasive

interventions in severe stenoses. These findings indicate that the availability of advanced support can modify therapeutic eligibility, expanding possibilities previously considered unfeasible.

Therapeutic decision-making, therefore, must integrate multiple axes: anatomical characteristics of the lesion, the patient’s clinical condition, presence of dynamic collapse, associated comorbidities, team experience, and available technological resources. The absence of a structured approach can result in repeated interventions, therapeutic failures, and increased morbidity.

Table 1

Determining factors in therapeutic decision-making in complex tracheal stenosis

Assessed Factor	Clinical Implication	Impact on Therapeutic Decision-Making
Stenosis length	Long segments are associated with greater surgical complexity	May limit primary resection; consider combined strategies
Cartilaginous involvement	Presence of rigid fibrosis and structural deformity	Favors indication for definitive surgical management
Dynamic collapse (tracheomalacia)	Reduces the effectiveness of isolated dilation	Evaluate prosthesis placement or segmental resection
Post-intubation etiology	Ischemic scarring process	High resolution rate with adequate resection
Extrinsic compression (e.g., goiter)	Associated anatomical alteration	Need for a combined surgical approach
Severe clinical condition	High anesthetic risk	Consider initial endoscopic approach or ECMO support
Availability of advanced support	Access to ECMO and a specialized team	Expands therapeutic possibilities

Source: Authors (2026)

In light of the above, it is evident that complex tracheal stenosis imposes integrated and sequential clinical reasoning. The decision should not be based exclusively on the severity of obstruction, but rather on a systemic analysis of the patient and the care context. Wang and Fan (2023) reinforce the need for

greater awareness of the relevance of post-intubation stenosis, noting that delayed diagnosis compromises therapeutic options. Souha et al. (2023) advocate a stepwise and personalized approach, beginning with less invasive interventions when appropriate, but without postponing definitive surgery when indicated.

Thus, therapeutic decision-making in complex tracheal stenosis should be understood as a dynamic process, sustained by multidisciplinary evaluation, careful risk–benefit analysis, and rational use of technological resources. The integration of recent scientific evidence and specialized clinical expertise constitutes a central element in achieving better outcomes and reducing recurrences, consolidating a care model based on individualization and patient safety.

COMPARATIVE RESULTS BETWEEN ENDOSCOPIC AND SURGICAL APPROACHES

Comparison between endoscopic and surgical approaches in the treatment of complex tracheal stenosis indicates that both play complementary roles, and outcomes vary according to anatomical characteristics of the lesion, etiology, clinical stability, and available institutional resources. Recent literature demonstrates that therapeutic choice should not be dichotomous, but guided by objective clinical criteria and the probability of sustained resolution of obstruction.

Within interventional pulmonology, endoscopic techniques have evolved significantly in recent decades. As highlighted by Gesthalter and Channick (2023), the expansion of the therapeutic arsenal—including balloon dilation, mechanical resection, cryotherapy, electrocautery, and prosthesis implantation—has consolidated therapeutic bronchoscopy as a central tool in the management of central airways. In patients with post-intubation stenosis, especially after prolonged mechanical ventilation, bronchoscopic interventions demonstrate immediate symptomatic improvement, reduction of dyspnea, and partial restoration of airflow (Ghiani et al., 2022).

However, studies indicate that long-term efficacy of exclusively endoscopic approaches may be limited in extensive cicatricial stenoses or those with significant cartilaginous compromise. Ayten et al. (2022), when analyzing post-intubation stenoses related to COVID-19, observed greater structural

complexity and a higher recurrence rate after repeated dilations. Similarly, Hong et al. (2024), in a systematic review, identified that factors such as prolonged intubation time and persistent inflammation are associated with greater risk of restenosis after conservative treatment.

On the other hand, tracheal surgery—especially resection with end-to-end anastomosis—offers higher rates of definitive resolution in appropriately selected patients. Boyko et al. (2025a) emphasize that surgical treatment of complex cicatricial stenoses can achieve satisfactory functional results when performed with adequate respiratory support and multidisciplinary planning. In a complementary study, Boyko et al. (2025b) highlight that the presence of associated thyroid pathologies requires technical adjustments but does not contraindicate the surgical approach, provided there is meticulous preoperative preparation.

Beyond efficacy, comparison between modalities must consider the complication profile. Endoscopic interventions have lower immediate morbidity, shorter hospital stay, and repeatability; however, they may result in granulation tissue formation, prosthesis migration, and the need for multiple procedures. In this context, Ayasa et al. (2025) describe the use of custom T-tubes as a personalized solution in complex stenoses, functioning as an intermediate alternative between simple dilation and definitive resection.

In particularly complex situations, such as stenoses associated with tracheoesophageal or bronchoesophageal fistulas, the surgical approach tends to yield better structural outcomes. Alhadid et al. (2025), in a two-decade case series, demonstrate that combined management—including surgical repair and endoscopic support—provides greater control of complications and lower recurrence compared with isolated interventions.

Incorporation of advanced technologies also influences comparative results. Kara et al. (2025) show that computational fluid dynamics analyses can predict changes in airflow after different interventions, assisting in choosing between dilation, prosthesis implantation, or segmental resection. This resource supports individualized planning and may reduce therapeutic failures.

Thus, comparative results indicate that endoscopic approaches are particularly advantageous in short, predominantly inflammatory stenoses or in patients at high surgical risk. Surgery, in turn, shows a higher rate of definitive resolution in long, recurrent cicatricial stenoses or those associated with significant structural deformity. Integration between the two—in a sequential or hybrid model—emerges as a superior strategy in terms of safety and effectiveness.

Table 2

Structured Comparison Between Endoscopic and Surgical Approaches in Complex Tracheal Stenosis

Axis of Analysis	Endoscopic Approach	Surgical Approach	Rationale
Indication Profile	Short, inflammatory stenoses; patients with high surgical risk or need for bridge therapy	Extensive, rigid, recurrent cicatricial stenoses or those associated with structural deformity	Dhaha <i>et al.</i> (2022)
Recurrence Rate	Higher risk of restenosis in complex lesions or post-COVID	Lower recurrence rate when resection is technically feasible	Ayten <i>et al.</i> (2022); Hong <i>et al.</i> (2024)
Technical Complexity	Minimally invasive procedures, repeatable	High-complexity procedure; requires a specialized center	Boyko <i>et al.</i> (2025a; 2025b)
Complications	Granulation formation, stent migration, need for multiple interventions	Anastomotic dehiscence, postoperative respiratory complications	Gesthalter, Channick (2023)
Associated Situations (e.g., fistulas)	Complementary or palliative role	Better structural control in complex tracheoesophageal fistulas	Alhadid <i>et al.</i> (2025)
Use of Advanced Technology	Personalized prostheses, advanced therapeutic bronchoscopy	Individualized surgical planning with technological support	Ayasa <i>et al.</i> (2025)

Patients with Associated Comorbidities (e.g., goiter)	May be an initial strategy in high-risk cases	Definitive approach combined with surgery for the underlying condition	Zuo et al. (2022)
Therapeutic Objective	Symptom control, stabilization, or bridge to surgery	Definitive anatomical correction of the airway	Ghiani et al. (2022)

Source: Authors (2026)

Comparative analysis shows that the superiority of one approach over the other is not absolute, but context-dependent. Gesthalter and Channick (2023) argue that interventional pulmonology has expanded therapeutic possibilities, reducing the need for immediate surgery in certain cases. However, Boyko et al. (2025a) emphasize that surgery remains irreplaceable when the objective is definitive structural correction of the airway.

Accordingly, results indicate that the best outcome is achieved when there is strategic integration between modalities, with a clear definition of the optimal timing for each intervention. The comparison should not be interpreted as competition between techniques, but as the construction of a rational therapeutic algorithm centered on the patient and supported by contemporary scientific evidence.

MULTIDISCIPLINARY MODEL, LONGITUDINAL CARE, AND FUTURE PERSPECTIVES

Acquired tracheal stenosis is a complex clinical condition, often resulting from prolonged intubation, mechanical ventilation, and tracheostomy, with significant functional impact and risk of life-threatening compromise. In this context, organizing care under a multidisciplinary model—associated with structured longitudinal follow-up—emerges as a central strategy to optimize clinical outcomes and reduce recurrences. Recent literature (2021–2026) converges on the need for integration among interventional pulmonology, thoracic surgery, anesthesiology, intensive care, radiology, specialized nursing, and, when indicated, extracorporeal support.

Characterization of epidemiology and risk factors constitutes the first structuring axis of care. Ghiani et al. (2022), when evaluating patients subjected to prolonged mechanical ventilation, demonstrated a relevant prevalence of tracheal stenosis and highlighted associated factors such as

intubation duration, tube diameter, and cuff pressure. Complementarily, Hong et al. (2024), in a systematic review and meta-analysis, reinforced that comorbidities, ventilation time, and local infection increase the risk of clinically significant stenosis. These findings support the need for preventive protocols in intensive care and for early screening, integrating intensivists and pulmonologists within the continuum of care.

In the diagnostic and initial therapeutic domain, bronchoscopy assumes a central role within the multidisciplinary model. Ravikumar et al. (2023) emphasize that bronchoscopy not only defines the extent, morphology, and degree of stenosis, but also guides shared therapeutic decisions between interventional pulmonologists and thoracic surgeons. According to the authors, team discussion allows selection of candidates for endoscopic dilation, laser application, stent placement, or early referral to tracheal resection. This approach reduces redundant interventions and facilitates more precise surgical planning.

Endoscopic therapy, when indicated, integrates longitudinal care as a strategy for symptom control and, in selected cases, as definitive treatment. Salloum et al. (2021) report favorable results in endoscopic treatment of post-intubation stenosis, with significant symptomatic improvement and a low rate of immediate complications. However, the authors recognize the need for repeated sessions in a portion of patients, reinforcing the importance of systematic follow-up and periodic multidisciplinary evaluation.

Technological advances have broadened diagnostic and therapeutic precision. Nathani et al. (2024) highlight the use of endobronchial ultrasonography and image-guided techniques as tools that increase procedural safety and accuracy. This technological incorporation requires specific training and team integration, consolidating the collaborative nature of the care model.

In complex or refractory cases, the surgical approach remains the gold standard, especially for extensive cicatricial stenoses. Souha et al. (2023) argue that the surgical decision should be made after a global assessment of the patient, considering lesion extent, clinical condition, and response to prior

interventions. Early integration of the thoracic surgeon into clinical discussion prevents therapeutic delays and reduces morbidity associated with multiple ineffective endoscopic interventions.

In situations of high anesthetic risk or critical airway compromise, advanced support strategies are incorporated into multidisciplinary care. Voltolini et al. (2024) demonstrate that the use of veno-venous ECMO in complex tracheobronchial resections increases intraoperative safety, enabling adequate oxygenation control in cases of critical obstruction. Similarly, Sierra and Székessy (2025) report the importance of awake fiberoptic intubation in patients with severe stenosis, emphasizing coordination between anesthesiologists and surgeons as a determinant for preventing airway collapse.

Therapeutic personalization also expands with tailored devices. Ayasa et al. (2025) describe the use of custom T-tubes in complex stenoses, integrating biomedical engineering into clinical management. This innovation exemplifies how the multidisciplinary model evolves to include collaboration with technological domains, aiming for individualized solutions.

From a longitudinal standpoint, structured follow-up is essential to monitor recurrences, assess airway patency, and adjust interventions. Wang and Tian (2022) underscore that post-intubation stenosis can progress even after apparent initial resolution, justifying regular clinical and endoscopic follow-up. Moreover, Alhadid et al. (2025), when analyzing tracheoesophageal and bronchoesophageal fistulas demonstrate that late complications require prolonged surveillance and intersectoral coordination.

Future perspectives point to integration of computational modeling and fluid dynamics analysis as decision-support tools. Kara et al. (2025) demonstrate that airflow simulations can predict the functional impact of different surgical approaches, paving the way for personalized planning based on objective data. Such advances suggest that multidisciplinary care will evolve to incorporate computational analysis and precision medicine.

Table 3

Components of the Multidisciplinary Model and Interfaces in Longitudinal Care of Tracheal Stenosis

Care Axis	Specialties Involved	Main Contributions	References
Prevention and Risk Identification	Intensive Care, Pulmonology	Control of risk factors, early screening	Ghiani <i>et al.</i> (2022); Hong <i>et al.</i> (2024); Wang e Tian (2022)
Diagnosis and Stratification	Interventional Pulmonology, Radiology	Diagnostic bronchoscopy, morphological assessment	Ravikumar <i>et al.</i> (2023); Nathani <i>et al.</i> (2024)
Endoscopic Therapy	Endoscopic Therapy	Dilation, laser, stents, serial follow-up	Salloum <i>et al.</i> (2021); Souha <i>et al.</i> (2023)
Surgical Approach	Thoracic Surgery, Anesthesiology	Tracheal resection, reconstruction, advanced airway management	Voltolini <i>et al.</i> (2024); Sierra and Székessy (2025)
Innovation and Personalization	Biomedical Engineering, Surgical Team	Custom tubes, computational modeling	Ayasa <i>et al.</i> (2025); Kara <i>et al.</i> (2025)
Longitudinal Follow-up	Integrated Multidisciplinary Team	Monitoring of recurrences, late complications	Alhadid <i>et al.</i> (2025); Wang and Tian (2022)

Source: Authors (2026)

In summary, contemporary results indicate that the multidisciplinary model is not merely an organizational arrangement, but a clinical determinant of favorable outcomes. Articulation among prevention, precise diagnosis, individualized therapeutic selection, and structured longitudinal follow-up reduces morbidity, optimizes resources, and increases safety. Future perspectives point to growing integration of advanced technologies and personalized medicine, consolidating a patient-centered, evidence-oriented paradigm.

CONCLUSION

Acquired tracheal stenosis remains a relevant clinical challenge in the contemporary context, especially given the increase in cases associated with prolonged mechanical ventilation and post-intubation complications. Recent literature demonstrates that its management requires integration among prevention, early diagnosis, appropriate therapeutic intervention, and structured longitudinal follow-up. Understanding risk factors and pathophysiological mechanisms—as evidenced by recent observational studies and meta-analyses—reinforces the need for standardized care protocols from intensive care through specialized outpatient follow-up.

Regarding therapeutic strategies, a complementarity between endoscopic and surgical approaches is observed, rather than an exclusive opposition. Endoscopic interventions—such as dilation, application of thermal energy, and device implantation—constitute effective alternatives for symptom control and for selected cases of short, non-complex stenoses. On the other hand, tracheal resection with reconstruction remains the gold standard in extensive or refractory cicatricial stenoses. The ideal therapeutic choice depends on a multidimensional assessment considering anatomical extent, clinical condition, history of prior interventions, and availability of institutional expertise.

The multidisciplinary model is consolidated as the structuring axis of care, integrating interventional pulmonology, thoracic surgery, anesthesiology, intensive care, radiology, and, in specific situations, extracorporeal support and biomedical engineering. This articulation favors shared decisions, individualized planning, and greater intraoperative safety, particularly in critical-airway scenarios. Moreover, incorporation of emerging technologies—such as customized devices and computational modeling of airflow—expands the possibilities for therapeutic personalization and tends to redefine paradigms of surgical planning.

Longitudinal care, in turn, constitutes an indispensable component for reducing recurrences and early detection of late complications, such as restenosis and tracheoesophageal fistulas.

Structured follow-up with periodic clinical and endoscopic assessment enables timely interventions and improves patients' quality of life. This perspective reinforces that tracheal stenosis management is not limited to initial treatment, but extends as a continuous process of monitoring and reassessment.

Despite the advances observed between 2021 and 2026, relevant gaps persist, especially regarding standardization of criteria for indicating each therapeutic approach, comparison of long-term outcomes, and cost-effectiveness analyses of available strategies. Methodological heterogeneity of current studies limits generalization of results and highlights the need for prospective investigations with robust samples and prolonged follow-up.

In this sense, development of a prospective multicenter study comparing endoscopic, surgical, and hybrid approaches in the treatment of acquired tracheal stenosis is suggested, incorporating quality-of-life analysis, five-year recurrence rates, care costs, and predictive computational modeling of functional outcomes. Integration of clinical, endoscopic, and simulation data may contribute to constructing an evidence-based decision algorithm oriented by personalized medicine, strengthening the multidisciplinary model and improving long-term clinical outcomes.

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