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CASE REPORT

Interdisciplinary Management of Severe Pediatric Subglottic Stenosis: A Case Report of Endoscopic Balloon Dilation Under Shared Airway Conditions

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ABSTRACT

Pediatric acquired subglottic stenosis is a high-risk airway condition that requires close coordination between anesthesiology and otorhinolaryngology teams, particularly during endoscopic interventions performed under shared-airway conditions. This report describes the interdisciplinary management and anesthetic–surgical coordination in a child with severe acquired subglottic stenosis undergoing endoscopic balloon dilation, highlighting key decision points and airway management strategies. A 2-year-old boy with a history of prolonged and repeated endotracheal intubations presented with persistent dyspnea and noisy breathing, consistent with fixed extrathoracic airway obstruction. The case was reviewed in a multidisciplinary pediatric difficult-airway meeting, and operative management consisted of endoscopic airway evaluation and balloon dilation performed under preserved spontaneous ventilation. Intraoperative endoscopy demonstrated approximately 80% subglottic luminal narrowing consistent with Cotton–Myer Grade III stenosis, and initial intubation across the stenotic segment was not possible. Radial scar release followed by sequential balloon dilations was successfully performed under shared-airway conditions. Transient oxygen desaturation occurred during balloon inflation but resolved with coordinated airway management and interval reoxygenation. Post-dilation airway calibration demonstrated improved patency. The patient was monitored postoperatively in the intensive care unit, extubated after 24 hours, and experienced no immediate complications. Short-term follow-up revealed stable respiratory status without recurrent symptoms, with planned staged surveillance and repeat dilation. This case demonstrates that severe pediatric subglottic stenosis can be managed safely with endoscopic balloon dilation when supported by meticulous interdisciplinary planning, preservation of spontaneous ventilation, and real-time communication between anesthesiology and surgical teams, potentially avoiding tracheostomy in selected high-risk pediatric patients.

Keywords: Pediatric airway, Subglottic stenosis, Balloon dilation, Difficult airway, Interdisciplinary management

1. Introduction

Acquired subglottic stenosis (SGS) in infants and young children represents a complex airway pathology in which both anesthesiologists and otolaryngologists must jointly navigate the competing priorities of ventilation, surgical exposure, and airway preservation. SGS most commonly arises as a consequence of prolonged translaryngeal intubation, mucosal injury, and subsequent cicatricial remodeling of the subglottic lumen [1]. The subglottic region is anatomically predisposed to injury because it forms the narrowest portion of the pediatric airway and is lined by a complete cartilaginous ring

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that limits expansion during inflammatory edema. Even brief periods of pressure-related mucosal ischemia may initiate ulceration, granulation, and progressive concentric scarring. In neonates and infants, these events can culminate in clinically significant fixed obstruction with stridor, recurrent respiratory distress, or failure of extubation [2].

The epidemiology of modern post-intubation SGS reflects improvements in neonatal ventilation practices, yet clinically significant stenosis continues to occur. Recent analyses report an incidence of approximately 11% among infants requiring invasive mechanical ventilation [3]. Children with extreme prematurity, chronic lung disease, or repeated intubations constitute the highest-risk subgroup [4]. In many cases, the disorder may be under-recognized, as mild or moderate SGS can masquerade as persistent wheezing, chronic lung disease, or upper airway reactivity until a difficult airway event unmasks the stenosis [4, 5].

Management of SGS is determined by the severity of luminal narrowing as graded by the Cotton–Myer classification, which stratifies obstruction based on endotracheal tube leak and sizing parameters [6]. Grades I and II are typically amenable to endoscopic approaches, whereas grades III and IV often require open laryngotracheal reconstruction or tracheostomy [6, 7]. Over the past two decades, endoscopic balloon dilation has emerged as a key therapeutic modality for selected cases, capitalizing on the radial, non-shearing force of balloon inflation to disrupt cicatricial stiffness while limiting additional mucosal trauma [8]. In appropriately selected patients, balloon dilation can reduce the need for open airway reconstruction by up to 80% [3], and multiple series have demonstrated favorable outcomes in infants and young children [8, 9]. In the present case, balloon dilation was favored as an initial airway-preserving strategy to avoid tracheostomy in a young child with high-grade but potentially reversible cicatricial stenosis, while allowing reassessment of airway patency under controlled endoscopic conditions.

Despite its efficacy, endoscopic dilation poses substantial perioperative challenges. The procedure requires operating within the same airway that the patient breathes through, creating a tightly interdependent workflow between anesthesiology and surgical teams. These “shared airway conditions” refer to situations in which airway instrumentation, surgical intervention, and ventilation must occur simultaneously within a single, often critically narrowed airway lumen. Mask ventilation may be difficult due to fixed subglottic narrowing, while laryngoscopy and attempts at intubation may further reduce airway stability or precipitate complete obstruction. [10]. In many cases, safe execution depends on preserving spontaneous ventilation to avoid loss of the airway during induction or surgical manipulation [3, 10]. Furthermore, children with chronic lung disease or recent infections may desaturate rapidly during apnea or balloon inflation, heightening the need for meticulous timing, communication, and contingency planning.

Given these constraints, high-risk SGS cases require comprehensive preoperative coordination among anesthesiologists, otolaryngologists, and pediatric pulmonologists, especially when tracheostomy is being avoided. Structured planning sessions, such as difficult-airway conferences, permit the development of shared mental models, anticipation of equipment needs, and preparation of backup strategies including micro-ETT oxygenation, nasopharyngeal insufflation, or emergent front-of-neck access [3, 4]. The ability to adapt intraoperatively, particularly when initial ventilation strategies fail or surgical access proves limited, is crucial for preventing catastrophic loss of the airway.

This report describes the multidisciplinary anesthetic and surgical management of a young child with high-grade acquired subglottic stenosis (Cotton–Myer Grade III) who underwent endoscopic balloon dilation under shared-airway conditions with preserved spontaneous ventilation. While both balloon dilation and spontaneous ventilation techniques are well established, this case is distinguished by the severity of stenosis and the need for real-time intraoperative coordination to maintain ventilation during airway intervention. The case highlights adaptive airway decision-making, continuous interdisciplinary communication, and the role of flexible anesthetic strategies in safely avoiding tracheostomy in a critically narrowed pediatric airway.

2. Case

Written informed consent was obtained from the patient’s legal guardians for publication of this case and accompanying images. Institutional approval was obtained according to hospital policy.

A 2-year-old boy with a history of recurrent pneumonia and repeated episodes of respiratory failure requiring prolonged intubation was referred for evaluation of persistent exertional dyspnea. He had been hospitalized multiple times throughout 2025 for febrile respiratory distress, culminating in two separate PICU admissions with mechanical ventilation; first for 14 days in June after respiratory failure and again in July for three days following a second decompensation. Although discharged without supplemental oxygen, he continued to experience intermittent tachypnea, noisy breathing when agitated,

and episodic increased work of breathing. Repeated chest radiographs demonstrated bilateral perihilar and paracardiac opacities, while high-resolution CT imaging later showed left lower lobe consolidation with cylindrical bronchiectasis and scattered bilateral ground-glass micronodules. The trachea and intrathoracic bronchi were patent, inflammatory markers remained normal, and tuberculosis studies were negative. His persistent symptoms, together with a history of prolonged intubations, raised suspicion for extrathoracic fixed airway obstruction. During a subsequent admission for worsening dyspnea, intermittent biphasic noisy breathing was noted, and flexible nasolaryngoscopy suggested subglottic narrowing. He was therefore scheduled for operative endoscopic airway evaluation and possible intervention.

The case had been reviewed in a multidisciplinary pediatric difficult-airway meeting, and an initial plan for tracheostomy under general anesthesia with a laryngeal mask airway (LMA) was established. Accordingly, a complete tracheostomy tray and rigid bronchoscopy equipment were prepared and immediately available in the operating room as airway rescue measures. On the day of surgery, inhalational induction with sevoflurane 8% in 100% oxygen was attempted; mask ventilation became difficult during apnea, so spontaneous ventilation was intentionally preserved. Standard intraoperative monitoring included continuous electrocardiography, pulse oximetry, noninvasive blood pressure measurement, and end-tidal carbon dioxide monitoring. After achieving sufficient anesthetic depth, an LMA size 1.5 was inserted. Anesthesia was maintained with sevoflurane supplemented by remifentanil administered via target-controlled infusion to provide analgesia and blunt noxious stimulation while preserving spontaneous respiration, consistent with institutional practice for shared-airway procedures. Bronchoscopy performed through the LMA by the pediatric pulmonologist revealed severe subglottic stenosis with approximately 80% luminal narrowing (Grade III stenosis) (Fig. 1), and the bronchoscope could not be advanced beyond the stenotic segment. Given the severity, the ENT team elected to proceed with primary balloon dilation to avoid immediate tracheostomy.

The LMA was removed, and suspension laryngoscopy using a Parson laryngoscope was performed. A 2.5-mm uncuffed endotracheal tube mounted on a camera could not be advanced across the stenosis (Fig. 2). Radial incisions were made at the 3 and 9 o'clock positions of the stenotic subglottic segment using a sickle knife to release the circumferential cicatricial ring, with care taken to avoid extension into the posterior cricoid plate. Oxygenation was maintained via a nasally inserted 3.0-mm endotracheal tube. Balloon dilation was performed using a high-pressure airway balloon catheter, beginning with a 6-mm diameter balloon and progressing sequentially to 8 mm and 10 mm. Each dilation was maintained for approximately 30 seconds at an inflation pressure of 6–8 atmospheres, with a 60-second interval between cycles to allow for reoxygenation and assessment of airway patency. A total of three dilation cycles were performed. During the dilation cycles, several

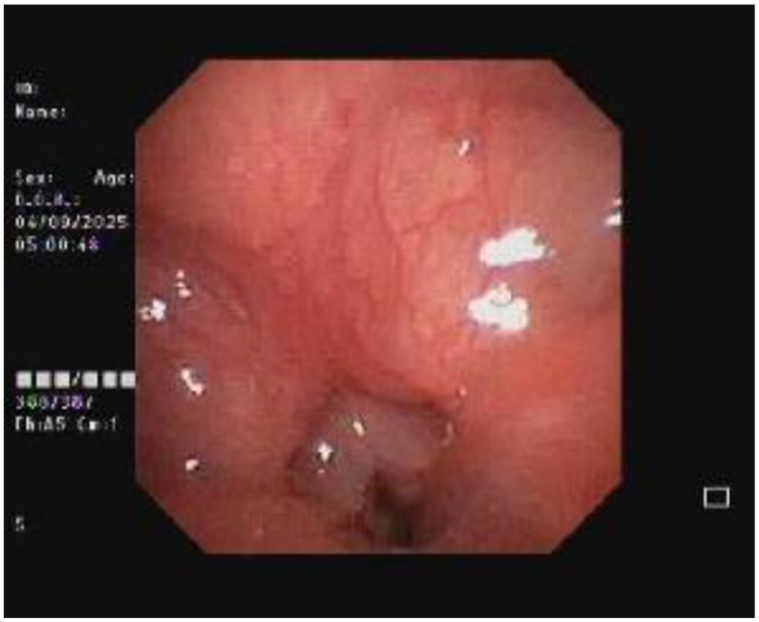

Fig. 1. 80% luminal narrowing seen through bronchoscopy.

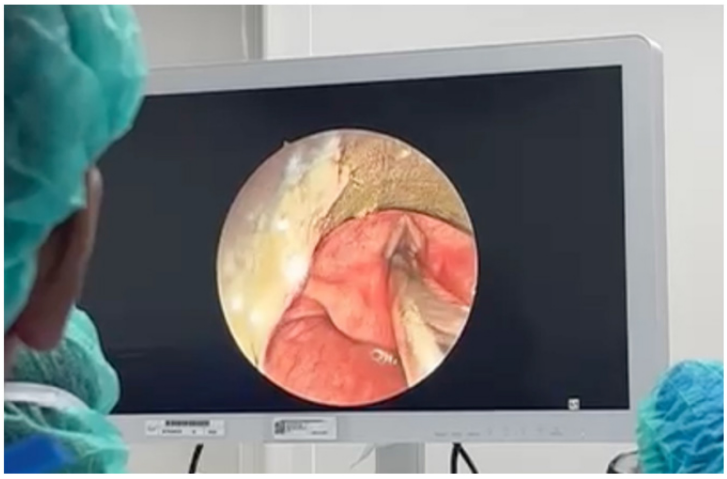

Fig. 2. Unsucesful attempt at inserting a 2.5-mm uncuffed ETT through the stenosis.

desaturation events occurred, with a nadir SpO_2 of 77%. During balloon inflation, ventilation was intentionally suspended due to complete luminal occlusion by the balloon catheter. Anesthesia was maintained with sevoflurane, preserving spontaneous ventilation, supplemented with intermittent apneic ventilation during balloon inflation and remifentanil target-controlled infusion titrated to surgical stimulation. Between dilation cycles, the patient was preoxygenated with 100% oxygen to optimize oxygen reserves prior to subsequent inflations. Balloon dilation duration was limited to approximately 1.5–2 minutes per cycle, based on operator preference and patient tolerance, and terminated earlier if oxygen saturation declined to 80%. This strategy was selected to balance effective radial expansion of the stenotic segment against the risk of hypoxemia, particularly in the context of limited pulmonary reserve. Ventilation was resumed immediately between dilation cycles to restore oxygen saturation before proceeding with subsequent inflations. At the conclusion of the procedure, the airway was calibrated with a 4.5-mm orotracheal tube, which passed without resistance.

Post-dilation bronchoscopy confirmed a patent tracheobronchial tree without additional lesions, and topical corticosteroids were applied to the dilated region. The patient was kept intubated and monitored in the intensive care unit, extubated after 24 hours, and received dexamethasone for three days. His postoperative course was stable without immediate complications. At one-week outpatient follow-up, the patient demonstrated stable respiratory status without stridor or signs of recurrent airway obstruction. At one month after the procedure, no recurrent respiratory symptoms were reported, and repeat endoscopic balloon dilation was planned as part of a staged management strategy with scheduled surveillance bronchoscopy.

3. Discussion

Acquired pediatric subglottic stenosis remains one of the most complex airway disorders encountered in infants and young children, largely because the disease develops at the intersection of prolonged intubation, mucosal injury, and inflammatory remodeling. In this age group, even brief periods of translaryngeal intubation can precipitate mucosal ischemia, ulceration, granulation, and eventually circumferential scar formation in the subglottis, which is anatomically the narrowest portion of the pediatric airway and uniquely predisposed to fixed obstruction [1]. Over the past two decades, balloon dilation has emerged as a minimally invasive option for restoring airway patency and limiting the need for open airway reconstruction or tracheostomy; however, its success is highly dependent on stenosis grade, chronicity, and overall airway condition. A recent systematic review of 14 studies involving 473 children reported a pooled success rate of 76%, while a larger meta-analysis encompassing more than 900 pediatric patients demonstrated an 84% success rate, confirming that balloon dilation can be effective in a substantial proportion of children with post-intubation SGS [11, 12]. These outcomes, however, decline significantly in higher Cotton–Myer grades or when dense, long-standing fibrotic rings predominate, underscoring the need for careful patient selection and procedural planning [13, 14].

The clinical course of the patient in this report reflects many features associated with more severe stenosis phenotypes. His history of recurrent pneumonia, multiple hospitalizations, and particularly two prolonged periods of mechanical ventilation created a high-risk substrate for acquired SGS. Although initial work-up focused on parenchymal lung disease, the persistence of dyspnea despite

radiographic improvement, the presence of exertional and agitation-provoked noisy breathing, and the absence of intrathoracic airway narrowing on CT were consistent with extrathoracic fixed obstruction. This diagnostic trajectory is common, as lower airway pathology frequently obscures underlying laryngeal disease in children with complex respiratory courses. Indeed, several series have shown that misattribution of symptoms to parenchymal lung infection is one of the most common causes of delayed diagnosis in pediatric SGS, particularly in children with bronchiectasis or chronic inflammatory lung disease [15, 16]. The decision to pursue endoscopic evaluation was therefore consistent with best practice, and the subsequent identification of approximately 80% luminal compromise confirmed the hemodynamic relevance of the stenosis.

Performing endoscopic balloon dilation in such patients requires meticulous coordination between otolaryngology and anesthesiology teams because the airway must simultaneously accommodate visualization, instrumentation, and ventilation. The anesthetic approach in this case—preserving spontaneous ventilation, using a laryngeal mask airway for initial bronchoscopy, and deferring neuromuscular blockade until airway anatomy had been characterized—aligns with established recommendations for managing severe subglottic obstruction in young children [3, 10]. Loss of spontaneous respiratory drive in a critically narrowed airway can precipitate rapid deterioration and an unventilatable state, particularly when mask ventilation becomes ineffective due to dynamic collapse or fixed obstruction. Tubeless or shared-airway techniques under spontaneous ventilation have therefore been advocated in specialized airway centers to minimize the risk of catastrophic airway loss during diagnostic and therapeutic endoscopy [15].

However, maintaining spontaneous ventilation while achieving adequate surgical conditions introduces a distinct anesthetic challenge: rigid laryngoscopy, subglottic instrumentation, radial incisions, and balloon inflation represent intense noxious stimuli that can provoke coughing, laryngospasm, or loss of airway control if analgesia is inadequate. In pediatric shared-airway surgery, hypnotic depth alone is often insufficient to blunt laryngeal reflexes without risking respiratory depression. Several authors have emphasized the importance of combining inhalational or intravenous anesthesia with targeted local anesthesia, including topical laryngeal anesthesia and submucosal or paralaryngeal lidocaine infiltration, to improve tolerance of airway manipulation while preserving spontaneous ventilation [3, 10]. Injection of lidocaine into the lateral laryngeal or subglottic tissues has been described as an effective adjunct to reduce reflex responses during rigid laryngoscopy and balloon dilation, allowing surgeons to operate under more stable conditions without escalating systemic anesthetic depth. Although not uniformly reported, this practice reflects an important anesthetic principle in pediatric airway surgery: optimizing local analgesia can expand the safety margin of spontaneous ventilation strategies by reducing airway reactivity during high-stimulation phases of the procedure.

Once the diagnosis of high-grade SGS was confirmed intraoperatively, the use of radial incisions followed by sequential balloon dilation reflected contemporary refinements in endoscopic management. Radial cold-knife incisions disrupt dense circumferential fibrous scar, reduce the shearing forces exerted by the balloon, and facilitate more uniform radial expansion of the airway lumen. Multiple pediatric series have demonstrated improved outcomes when radial incisions are used adjunctively, particularly in dense cicatricial rings or recurrent stenosis [8]. Sequential balloon dilations, although associated with transient desaturation episodes—as observed in this case—remain the core therapeutic maneuver for restoring airway caliber. Desaturation to 77% falls within the range reported in high-grade stenosis, where temporary airway occlusion during full balloon inflation is unavoidable. Importantly, major complications such as airway rupture, pneumomediastinum, hemorrhage, or emergent tracheostomy remain uncommon when careful technique and continuous interdisciplinary communication are maintained [13, 17]. The postoperative application of topical corticosteroids is widely practiced to reduce mucosal inflammation and edema following endoscopic airway manipulation, with the aim of limiting early granulation tissue formation and potentially delaying restenosis, particularly in high-grade cicatricial stenosis, although long-term outcome data remain limited [8].

Short-term outcomes following balloon dilation in pediatric SGS are generally favorable, but procedural durability varies according to stenosis severity, chronicity, and comorbid airway or lung disease. Children with grade II–III stenosis frequently require repeat dilations, particularly when chronic lung disease or recurrent infection persists. Small series of serial balloon dilations have reported sustained airway patency for up to 21 months with staged interventions, suggesting that repeated endoscopic management may provide lasting benefit even in advanced disease [18]. More recently, quality-of-life studies have demonstrated improvements not only in respiratory symptoms but also in functional and psychosocial domains following successful dilation, supporting the broader clinical impact of airway restoration [19].

The experience in this case highlights several principles relevant to the management of severe pediatric SGS. Early interdisciplinary evaluation is critical, particularly when pulmonary imaging abnormalities coexist with prior intubation history. Anesthetic strategies that preserve spontaneous ventilation while incorporating sufficient local and systemic analgesia are essential for safe shared-airway surgery. Adjunctive techniques such as paralaryngeal lidocaine infiltration may further enhance procedural tolerance and stability during rigid laryngoscopy. Finally, postoperative planning must anticipate the risk of restenosis and the influence of underlying lung disease on long-term outcomes. While balloon dilation does not replace open laryngotracheal reconstruction in all cases, this report supports its role as an effective, airway-sparing first-line intervention when performed within a carefully coordinated multidisciplinary framework. This report is limited by its single-case design, short follow-up duration, and absence of long-term airway outcome data, which preclude definitive conclusions regarding durability and generalizability; nevertheless, it provides practical insight into multidisciplinary decision-making in high-risk pediatric airway management.

4. Conclusion

This case demonstrates that endoscopic balloon dilation, when performed within a well-coordinated interdisciplinary framework, can provide a safe and effective airway-preserving alternative to tracheostomy in children with severe acquired subglottic stenosis. Early recognition of extrathoracic obstruction, careful anesthetic planning that preserves spontaneous ventilation, and precise endoscopic techniques, including radial scar lysis and graded balloon dilation, were critical in achieving airway patency despite the patient's high-risk profile and significant pulmonary comorbidities. Although the long-term durability of balloon dilation varies and close follow-up remains essential, this experience reinforces the value of proactive multidisciplinary collaboration in optimizing outcomes in complex pediatric airway disease.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

This is an observational study. The Faculty of Medicine Universitas Indonesia Research Ethics Committee has confirmed that no ethical approval is required.

Data availability

No datasets were generated or analyzed during the current study.

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Author contribution

Margaretha Gunawana: Conceptualization, methodology, project administration. Syahrial Marsintha Hutauruk: Supervision, writing – review and editing. Fauziah Fardizza: Supervision, writing – review and editing. Christopher Kapuangan: Supervision, writing – review and editing. Mikhael Yosia: Data curation, formal analysis, writing – original draft preparation.

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