Section: Anaesthesiology

Case Series

CHALLENGES AND TECHNIQUES IN AIRWAY MANAGEMENT DURING ENDOSCOPIC BALLOON DILATATION OF TRACHEAL STENOSIS: A SINGLE CENTRE CASE SERIES

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ABSTRACT

Background: Endoscopic balloon dilatation is an effective minimally invasive treatment for tracheal stenosis; however, it presents significant anesthetic challenges due to the shared airway and requirement for intermittent interruption of ventilation during balloon inflation. Various ventilation strategies have been described, but there is no universally accepted anesthetic technique. We present our experience of anesthetic management and perioperative outcomes in patients undergoing balloon tracheal dilatation for tracheal stenosis.

Materials and Methods: This retrospective observational case series included 14 consecutive patients who underwent endoscopic balloon dilatation for tracheal stenosis. Demographic characteristics, airway assessment, presence of tracheostomy, anesthetic technique, ventilation strategy, intraoperative events, and postoperative outcomes were analysed. All patients received total intravenous anesthesia (TIVA) with propofol. High-flow nasal oxygen (HFNO) was used throughout the procedure for apnoeic oxygenation. Patients with pre-existing tracheostomy were managed with controlled ventilation through the tracheostomy tube after induction of anesthesia with neuromuscular blockade. Non-tracheostomized patients were managed with intermittent bag-mask ventilation without routine neuromuscular blockade. Ventilation was interrupted during balloon inflation and resumed between dilatation cycles.

Results: Fourteen patients underwent balloon tracheal dilatation during the study period. The majority of patients were young adults, belonging to 20–30-year age group. There was an equal distribution of males and females. Eight patients (57.1%) had a pre-existing tracheostomy, while six patients (42.9%) underwent the procedure through the native airway. The duration of procedures ranged from 30 to 60 minutes. Balloon dilatation was performed using repeated inflation cycles, with a median of 3 cycles per patient (range: 2–5). The duration of ventilation interruption during balloon inflation ranged from 30–60 seconds per cycle. Continuous HFNO with intermittent ventilation maintained adequate oxygenation throughout the procedure. No patient required conversion to emergency airway intervention or procedure abandonment. No major perioperative complications or mortality, were observed.

Conclusion: A carefully planned anesthetic strategy using propofol-based TIVA, continuous HFNO, and ventilation techniques individualized according to airway anatomy allowed safe completion of balloon tracheal dilatation in our series. Intermittent ventilation combined with HFNO may represent a practical and effective approach for managing the shared airway during endoscopic treatment of tracheal stenosis.

Keywords: Tracheal stenosis; Balloon dilatation; High-flow nasal oxygen; Shared airway; Tracheostomy.

INTRODUCTION

Anesthetic management for tracheobronchial procedures is challenging because the anaesthesiologist and surgeon share the airway, requiring meticulous planning, close communication, and coordinated airway management. Despite advances in airway devices and anesthetic techniques, high-level evidence guiding the optimal anesthetic strategy for tracheal interventions remains limited.

Post-intubation tracheal stenosis accounts for approximately 75% of cases requiring airway intervention, followed by airway or pulmonary malignancies and congenital abnormalities.[1] Tracheal stenosis may be broadly classified as structural or dynamic. Structural stenosis results from fixed narrowing due to fibrosis, granulation tissue, tumors, extrinsic compression, or airway distortion, whereas dynamic stenosis results from weakness of the tracheal cartilage or excessive posterior membranous wall collapse.[2-4] Clinical symptoms correlate with the degree of luminal narrowing, with exertional dyspnoea commonly occurring when the lumen is reduced by approximately 50%, while stridor at rest suggests severe obstruction.[5,6]

Patients with significant tracheal stenosis may present unique anesthetic challenges, including difficult ventilation, worsening of obstruction following induction and neuromuscular blockade, inability to advance an endotracheal tube beyond the stenosis, and impaired gas exchange during airway manipulation. Preservation of spontaneous ventilation and awake airway techniques may therefore be appropriate in selected high-risk patients.[7-9]

Balloon dilatation using rigid bronchoscopy is commonly employed for the treatment of tracheal stenosis but presents additional challenges because of the shared airway and intermittent interruption of ventilation during balloon inflation. Various anesthetic and ventilation techniques have been described, although no standardized approach has been universally established.

We present our institutional experience with the anesthetic management, airway strategies, and perioperative outcomes of patients with tracheal stenosis undergoing balloon dilatation using rigid bronchoscopy.

MATERIALS AND METHODS

Study design: This retrospective observational case series was conducted in the Department of Anaesthesiology in collaboration with the Department of Otorhinolaryngology at Indira Gandhi Government Medical College (IGGMC), Nagpur. Following approval from the Institutional Ethics Committee, the medical records of patients who underwent endoscopic balloon dilatation for tracheal stenosis between December 2024 and July 2026 were reviewed.

Demographic characteristics, presence of tracheostomy, anesthetic technique, intraoperative airway management, perioperative complications, and postoperative outcomes were retrieved from the anesthesia records and hospital information system.

Anesthetic management: All procedures were performed in a dedicated operating room by consultant anesthesiologists experienced in shared-airway procedures in close coordination with the otorhinolaryngology team. A preoperative airway management plan was formulated after review of the clinical history, computed tomography (CT) imaging, bronchoscopic findings, and airway anatomy.

Standard American Society of Anaesthesiologists (ASA) monitoring, including continuous electrocardiography, non-invasive blood pressure, pulse oximetry, capnography, and temperature monitoring, was instituted. Intravenous access was established using an 20G cannula. A difficult airway cart, fiberoptic bronchoscope, rigid bronchoscope, tracheostomy tubes of various sizes, and emergency surgical airway equipment were readily available.

Patients were preoxygented with 100% oxygen for 3–5 minutes. High-flow nasal oxygen (HFNO) was initiated before induction at a flow rate of 50–60 L/min with an FiO_2 of 1.0 and continued throughout the procedure to provide apnoeic oxygenation during periods of interrupted ventilation.

General anesthesia was induced with intravenous fentanyl (2 µg/kg) and propofol (2.5 mg/kg). Anesthesia was maintained using total intravenous anesthesia (TIVA) with a continuous propofol infusion (100–200 µg/kg/min), titrated to maintain adequate anesthetic depth. Supplemental fentanyl was administered when required.

Patients with tracheostomy: Eight patients had a mature tracheostomy at presentation. After induction of anesthesia, atracurium (0.5 mg/kg) was administered to facilitate controlled ventilation through tracheostomy tube. Once adequate anesthetic depth was achieved, the tracheostomy tube was removed to permit endoscopic access to the stenotic segment. During balloon inflation, ventilation was temporarily interrupted while HFNO was continued. Following balloon deflation, ventilation was re-established through the tracheostomy tube until satisfactory oxygenation was achieved before subsequent inflation cycle.

Patients without tracheostomy: The remaining six patients were managed through the native airway. Following induction with fentanyl and propofol, intermittent bag-mask ventilation was employed throughout the procedure without routine administration of depolarizing neuromuscular blockade. HFNO was maintained continuously during the procedure. Ventilation was interrupted during balloon inflation and resumed between successive inflation cycles until oxygen saturation returned to acceptable levels.

Intraoperative management: Balloon tracheal dilatation was performed under rigid bronchoscopic guidance by the otorhinolaryngology team. Balloon size (Figure 1), inflation pressure, number of inflation cycles, and duration of inflation were determined by the operating surgeon according to the characteristics of the stenotic segment. Individual balloon inflations generally lasted 30–60 seconds, followed by intermittent ventilation.

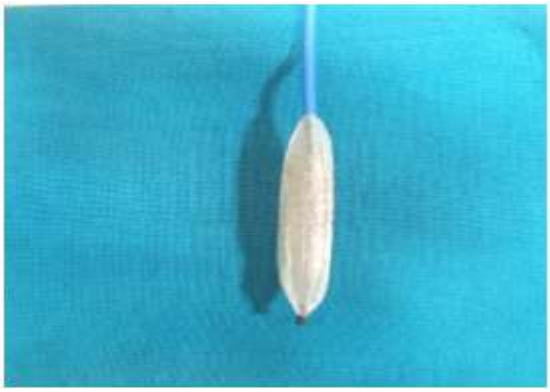

Figure 1: Image showing balloon dilator

Continuous communication between the anaesthesiology and surgical teams was maintained throughout the procedure to coordinate periods of apnoea and ventilation. Hemodynamic variables and oxygen saturation were monitored. Episodes of hypoxemia (SpO_2 <90%), difficult ventilation, airway bleeding, bronchospasm, laryngospasm, arrhythmias, and the need for rescue airway interventions were recorded.

At the completion of procedure, the tracheostomy tube was reinserted in patients with pre-existing tracheostomy. Residual neuromuscular blockade was reversed with neostigmine (50 µg/kg) and glycopyrrolate (10 µg/kg) following confirmation of adequate spontaneous respiratory effort. Patients were subsequently observed in the post-anesthesia care unit.

Outcome measures

The primary outcome was successful completion of balloon tracheal dilatation without major airway-related complications.

Secondary outcomes included:

- Intraoperative oxygen desaturation (SpO_2 <90%);
- need for rescue airway intervention or conversion to an alternative ventilation strategy;
- airway-related complications (bleeding, laryngospasm, bronchospasm, arrhythmias);
- postoperative ICU admission; and
- Perioperative mortality.

Statistical analysis: Data were analysed using IBM SPSS Statistics version 21 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation or median (interquartile range), depending on their distribution. Categorical variables were summarized as frequencies and percentages.

RESULTS

A total of 14 patients underwent endoscopic balloon dilatation for tracheal stenosis. All patients were young adults, with the entire cohort belonging to 20–30 years age group. There was an equal gender distribution, with 7 males and 7 females. All patients were classified as ASA Physical Status I. Eight patients (57.1%) had a pre-existing tracheostomy, whereas six patients (42.9%) underwent the procedure through the native airway.

All procedures were successfully completed under general anesthesia using a standardized propofol-based total intravenous anesthesia (TIVA) technique. Patients with tracheostomy received neuromuscular blockade to facilitate controlled ventilation through the tracheostomy tube, while patients without tracheostomy were managed with intermittent bag-mask ventilation combined with continuous high-flow nasal oxygen (HFNO).

The duration of the procedures ranged from 30 to 60 minutes. [Table1]

Table 1: Baseline patient characteristics

Variable	Value
Number of patients	14
Age group (20–30 years)	14 (100%)
Male	7
Female	7
ASA I	14(100%)
No comorbidities	14(100%)
Tracheostomy present	8 (57.1%)
No tracheostomy	6 (42.9%)
Procedure duration	30–60 min

ASA: American Society of Anesthesiologists; HFNO: high-flow nasal oxygen. Data are presented as number (percentage) unless otherwise specified.

Airway and anesthetic outcomes: Balloon tracheal dilatation was performed under rigid bronchoscopic guidance using repeated inflation-deflation cycles. The median number of balloon inflation cycles was 3 per patient (range 2–5). Each balloon inflation resulted in a temporary interruption of ventilation, with an apnea duration of approximately 30–60 seconds per cycle.

Continuous HFNO was used in all patients throughout the procedure. The lowest recorded intraoperative oxygen saturation was 85%. Transient desaturation (SpO_2 <90%) occurred in 4 patients

(28%), all of whom responded promptly to resumption of ventilation between balloon inflation cycles.

No patient required rescue endotracheal intubation, emergency rigid bronchoscopy-assisted ventilation, emergency surgical airway intervention, or conversion to an alternative ventilation technique. [Table 2]

Table 2: Airway and anesthetic outcomes

Variable	Value
TIVA with propofol	14 (100%)
HFNO used continuous	14 (100%)
Bag-mask ventilation	6 (42.9%)
Ventilation via tracheostomy	8 (57.1%)
Muscle relaxant used	8 (57.1%)
Lowest SpO_2	85 %
Duration of each inflation/apneic period	30–60 sec
Balloon inflation cycles	Median 3 (range 2–5)
Rescue ventilation required	None
Conversion to alternative airway technique	none

TIVA: total intravenous anesthesia; HFNO: high-flow nasal oxygen; SpO_2: peripheral oxygen saturation. Data are presented as number (percentage) unless otherwise specified. Balloon inflation cycles and apnea duration represent the intraoperative periods of ventilation interruption during endoscopic balloon dilatation.

Perioperative complications: No major anesthesia-related complications, including complete airway obstruction, aspiration, pneumothorax, significant airway trauma, cardiac arrest, or perioperative mortality, were observed.

Minor complications included transient hypoxemia in 4 patients (28%) and airway bleeding in 2 patients (14%). No episodes of bronchospasm or laryngospasm were recorded. All complications were managed successfully with conservative measures, and no patient experienced persistent postoperative sequelae.

DISCUSSION

Endoscopic balloon dilatation for tracheal stenosis is a challenging airway procedure because it involves a shared airway between the anaesthesiologist and the surgeon. The primary anesthetic objectives during these procedures are maintaining adequate oxygenation and ventilation, preventing airway compromise, providing optimal conditions for surgical intervention, and ensuring rapid restoration of airway patency following periods of interrupted ventilation. In this case series of 14 patients undergoing balloon tracheal dilatation, we successfully managed all procedures using propofol-based total intravenous anesthesia (TIVA), continuous high-flow nasal oxygen (HFNO), and ventilation strategies individualized according to the presence or absence of a tracheostomy.

Tracheal stenosis is most frequently encountered as a consequence of prolonged endotracheal intubation and tracheostomy. The young age group and absence of significant comorbidities in our cohort are consistent with the typical clinical profile of patients presenting with benign post-intubation airway stenosis. These patients often require repeated endoscopic interventions, and the anesthetic plan must account for the severity of airway narrowing and the potential for rapid deterioration during induction and airway manipulation.

Patients with significant tracheal stenosis pose unique anesthetic challenges. Induction of anesthesia and administration of neuromuscular blockade can result in loss of spontaneous respiratory effort and reduction in airway calibre, potentially leading to complete airway obstruction in patients with critical narrowing. Therefore, maintenance of spontaneous ventilation during induction or awake airway management has traditionally been recommended in selected high-risk patients.[8,9] In our series, airway management was individualized based on the presence of a tracheostomy. Neuromuscular blockade was used only in patients with established tracheostomies, where controlled ventilation could be reliably achieved. Patients without tracheostomy were managed without routine neuromuscular blockade using intermittent bag-mask ventilation combined with HFNO.

The anesthetic management of narrowed airways requires careful preparation and a tailored approach because no single technique is suitable for all patients. Blank and de Souza emphasized that airway procedures involving tracheal stenosis require detailed preoperative assessment, anticipation of airway loss, availability of rescue equipment, and close communication between anesthesia and surgical teams.[10] In our study, all procedures were performed with a predefined airway strategy, availability of advanced airway equipment, and continuous coordination with the surgical team, which likely contributed to the successful completion of all procedures without major airway complications.

Various ventilation techniques have been described for endoscopic treatment of airway stenosis, including spontaneous ventilation, intermittent positive pressure ventilation, jet ventilation, Supraglottic airway-assisted ventilation, and newer flow-controlled ventilation techniques. The choice of

technique depends on the anatomical location and severity of stenosis, procedural requirements, and institutional expertise. Reviews of anesthesia for tracheal surgery emphasize that effective teamwork, appropriate equipment preparation, and anticipation of complications are essential components of safe airway management during these procedures.[11,12]

In our cohort, propofol-based TIVA was used in all patients. TIVA provides several advantages during shared airway procedures, including rapid titration, suppression of airway reflexes, reduced patient movement, and predictable recovery characteristics. These properties are particularly useful during procedures requiring repeated airway manipulation, intermittent ventilation, and coordination between the anaesthesiologist and surgeon. Blank and de Souza have highlighted the role of intravenous anesthesia techniques in facilitating controlled conditions during complex airway interventions.[10]

HFNO was used continuously in all patients in our study as an adjunct to oxygenation during periods of interrupted ventilation. HFNO provides heated and humidified oxygen at high flow rates, generates a degree of positive airway pressure, and facilitates apnoeic oxygenation by maintaining oxygen delivery into the airway. However, carbon dioxide clearance remains limited during prolonged apnoea, and therefore HFNO should be considered a supportive technique rather than a substitute for ventilation. The physiological principles and limitations of apnoeic oxygenation have been described by Huitink and Bouwman, who emphasized that oxygenation can be prolonged during apnoea, but progressive carbon dioxide accumulation remains inevitable.[13]

Patel and Nouraei described transnasal humidified rapid-insufflation ventilatory exchange (THRIVE), demonstrating that high-flow nasal oxygen can significantly prolong safe apnoea time during airway management procedures.[14] Although our patients underwent repeated short periods of ventilation interruption rather than prolonged apnoea, continuous HFNO likely contributed to maintaining oxygen reserve during balloon inflation cycles.

A systematic review by Mangahas et al. evaluating anesthetic techniques for airway stenosis procedures demonstrated that multiple ventilation strategies can be safely employed, with selection based on patient factors and procedural requirements rather than a single preferred method.[11] The review also highlighted the increasing use of HFNO and other advanced ventilation strategies in endoscopic airway procedures. In our series, intermittent bag-mask ventilation combined with HFNO in non-tracheostomized patients provided adequate oxygenation without the need for jet ventilation or more complex airway techniques.

Patients with pre-existing tracheostomy represented 57.1% of our cohort. In these patients, controlled ventilation through the tracheostomy tube following induction and neuromuscular blockade allowed reliable ventilation before and between balloon inflation cycles. Temporary removal of the tracheostomy tube during balloon dilatation permitted adequate bronchoscopic access while maintaining the option of rapid reinstitution of ventilation.

The duration of procedures in our study ranged from 30 to 60 minutes, with a median of three balloon inflation cycles per patient and individual inflation periods lasting 30–60 seconds. Despite repeated interruptions in ventilation, all procedures were completed successfully. Transient hypoxemia occurred in four patients (28%), with the lowest recorded oxygen saturation being 85%; however, all episodes resolved promptly following resumption of ventilation. No patient required rescue intubation or emergency surgical airway intervention.

The absence of major complications in our series may be attributed to careful patient selection, detailed preoperative airway assessment, availability of rescue equipment, continuous HFNO administration, and close communication between the anaesthesiology and surgical teams.

Our study has several limitations. The retrospective design, single-centre experience, and small sample size limit the ability to draw definitive conclusions regarding the superiority of this technique compared with alternative ventilation strategies. Additionally, a control group was not available for comparison with other approaches such as jet ventilation or spontaneous ventilation techniques.

CONCLUSION

In conclusion, our experience demonstrates that propofol-based TIVA combined with continuous HFNO and individualized ventilation strategies can facilitate safe anesthetic management during balloon tracheal dilatation. Intermittent bag-mask ventilation in non-tracheotomised patients and controlled ventilation through tracheostomy in tracheotomised patients provided satisfactory procedural conditions without major airway-related complications. Careful planning, anticipation of airway difficulties, and effective multidisciplinary communication remain the key elements for successful management of these complex airway procedures.

REFERENCES

1. Grillo HC, Donahue DM. Post intubation tracheal stenosis. Semin Thorac Cardiovasc Surg 1996;8:370-80.
2. Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2013;118:251-70.
3. Freitag L, Ernst A, Unger M, et al. A proposed classification system of central airway stenosis. Eur Respir J 2007;30:7-12.
4. Faust RA, Remley KB, Rimell FL. Real-time, cine magnetic resonance imaging for evaluation of the pediatric airway. Laryngoscope 2001;111:2187-90.
5. Al-Bazzaz F, Grillo H, Kazemi H. Response to exercise in upper airway obstruction. Am Rev Respir Dis 1975;111:631-40.

6. Touat L, Fournier C, Ramon P, et al. Intubation-related tracheal ischemic lesions: incidence, risk factors, and outcome. Intensive Care Med 2013;39:575-82
7. Tapia B, Garcia R, Arag_on P, Castro A, Garrido E, Gilsanz F. Subglottic stenosis: airway management and intraoperative haemodynamic monitoring. Anaesth Cases 2017; 5: 30e3
8. Isono S, Kitamura Y, Asai T, Cook TM. Case scenario: perioperative airway management of a patient with tracheal stenosis. Anesthesiology 2010; 112: 970e8
9. Marwaha A, Kumar A, Sharma S, Sood J. Anaesthesia for tracheal resection and anastomosis. J Anaesthesiol Clin Pharmacol 2022; 38: 48e57
10. Blank RS, de Souza DG. Anesthetic management of the narrowed airway. Anesthesiol Clin. 2019;37(4):675–692.
11. Mangahas AM, Talugula S, Husain IA. Anesthesia considerations during management of airway stenosis: A systematic review. Am J Otolaryngol. 2023;44(2):103767.
12. Prakash D, et al. Anaesthesia for tracheal resection and anastomosis. Indian J Anaesth. 2022;66(Suppl 2):S126–S133.
13. Huitink JM, Bouwman RA. The myth of apnoeic oxygenation. Br J Anaesth. 2015;115(3):361–364.
14. Patel A, Nouraei SAR. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE): A physiological method of increasing apnoea time in patients with difficult airways. Anaesthesia. 2015;70(3):323–329.