

Anaesthetic Management of Tracheal Dilation in Post-Tracheostomy Subglottic Stenosis with Suspected Tracheomalacia: A Dexmedetomidine-Based Spontaneous Ventilation Technique — A Case Report

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Publication Date: 2026/09/23

Abstract: Prolonged mechanical ventilation via tracheostomy is a recognised cause of acquired subglottic and tracheal stenosis. Anaesthetic management for endoscopic tracheal dilation in such patients is challenging, particularly when co-existing tracheomalacia raises concern for dynamic airway collapse with neuromuscular blockade, and when concurrent laser use mandates a low fraction of inspired oxygen (FiO₂). We report the case of a 23-year-old male who developed Cotton-Myer grade III subglottic/tracheal stenosis after four months of tracheostomy-assisted ventilation following exploratory laparotomy for blunt abdominal trauma. He underwent tracheal dilation using a muscle-relaxant-free, spontaneous-ventilation technique with a dexmedetomidine infusion (loading dose 1 mcg/kg over 10 minutes, maintenance 0.3 mcg/kg/hour), high-dose fentanyl, and a supraglottic airway device (i-gel), at low FiO₂ to accommodate simultaneous laser use. This approach preserved spontaneous respiration, avoided airway collapse, minimised operating room pollution, and maintained an adequate depth of anaesthesia throughout the procedure.

Keywords: Dexmedetomidine; Subglottic Stenosis; Tracheomalacia; Spontaneous Ventilation; Tubeless Anaesthesia; Laser Airway Surgery; Tracheal Dilation.

How to Cite: Ajit Kumar; Umang Sharma; Mohammad Azhar Khan; Tanzim Akram; Abhisek Dey (2026) Anaesthetic Management of Tracheal Dilation in Post-Tracheostomy Subglottic Stenosis with Suspected Tracheomalacia: A Dexmedetomidine-Based Spontaneous Ventilation Technique — A Case Report. *International Journal of Innovative Science and Research Technology*, 11(9), 888-891. <https://doi.org/10.38124/ijisrt/26sep834>

I. INTRODUCTION

Acquired subglottic/tracheal stenosis is a well-known complication of prolonged intubation or tracheostomy, resulting from mucosal ischaemia, ulceration, and subsequent scar formation at the level of the cuff, stoma, or tracheostomy tube tip. The Cotton-Myer classification grades the severity of stenosis from I to IV based on percentage luminal obstruction, with grade III representing 71–99% occlusion of the airway, a critical narrowing with minimal reserve for further compromise. When such stenosis coexists with tracheomalacia (weakening and dynamic collapse of the tracheal cartilage, itself another sequela of prolonged tracheostomy), the anaesthetic goal shifts from simply securing the airway to preserving airway patency through active muscle tone, since loss of spontaneous respiratory effort

and neuromuscular blockade can precipitate dynamic collapse of the malacic segment distal to the stenosis.

Endoscopic procedures on such airways additionally require a “shared airway” technique, often complicated by the use of laser, which mandates minimisation of FiO₂ to reduce fire risk. We describe the anaesthetic management of tracheal dilation in a young adult with post-traumatic, post-tracheostomy subglottic stenosis and suspected tracheomalacia, using a dexmedetomidine-based total intravenous technique that preserved spontaneous ventilation throughout.

II. CASE REPORT

A 23-year-old male (weight 65 kg) presented with progressive stridor and exertional breathlessness. His history

was significant for blunt abdominal trauma, following which he underwent emergency exploratory laparotomy. His post-operative course was complicated, requiring admission to the trauma intensive care unit and prolonged mechanical ventilatory support via tracheostomy for approximately four months. Following eventual weaning and decannulation, he developed progressive stridor and was subsequently diagnosed with subglottic/tracheal stenosis, endoscopically graded as Cotton-Myer grade III, with the tracheal lumen markedly narrowed by circumferential scar and granulation tissue (Fig. 1). Written informed consent was obtained from the patient for the procedure and for publication of this report along with accompanying de-identified clinical images.

Tracheomalacia of the adjacent segment was also suspected clinically given the prolonged tracheostomy course, raising concern that abolishing airway muscle tone with a neuromuscular blocking agent could precipitate dynamic collapse of the weakened tracheal wall distal to the stenosis and result in loss of the airway. He was posted for endoscopic tracheal dilation with adjunct laser-assisted division of scar tissue. Given the anaesthetic concerns outlined above, the multidisciplinary team elected against the use of any muscle relaxant, and a spontaneous-ventilation, tubeless technique was planned.

In the operating room, standard ASA monitoring (electrocardiography, pulse oximetry, non-invasive blood pressure and capnography) was instituted, along with baseline arterial blood gas sampling. A dexmedetomidine infusion was started with a loading dose of 1 mcg/kg administered over the initial 10 minutes. Anaesthesia was induced with a high-dose fentanyl bolus (approximately 3 mcg/kg) to blunt airway reflexes and provide analgesia while sparing spontaneous respiratory drive as far as possible, and an i-gel supraglottic airway device was placed to maintain a patent conduit alongside the working channel for the endoscope while preserving spontaneous respiration. Anaesthesia was thereafter maintained with a background dexmedetomidine infusion at 0.3 mcg/kg/hour, titrated to maintain adequate depth without respiratory depression.

Throughout the laser-assisted portion of the procedure, FiO₂ was deliberately kept low to minimise the risk of airway fire, consistent with established laser airway safety practice, while oxygenation was monitored continuously via pulse oximetry and intra-procedural arterial blood gas analysis (pH 7.395, pCO₂ 39.9 mmHg, pO₂ 81.1 mmHg, HCO₃⁻ 23.9 mmol/L; Table 1).

Spontaneous ventilation was preserved throughout the procedure. The patient maintained adequate oxygenation and ventilation, and the airway did not collapse at any point despite the absence of neuromuscular blockade. Endoscopic dilation and laser division of the stenotic segment were completed successfully (Fig. 2 and Fig. 3), with satisfactory improvement in the visualised lumen. The technique also had the secondary benefit of markedly reduced operating room pollution compared with a volatile-agent-based spontaneous ventilation technique, since anaesthesia was maintained entirely

intravenously. The patient was haemodynamically stable throughout and recovered uneventfully.

Table 1 Intraoperative Arterial Blood Gas and Electrolyte Profile

Parameter	Value (reference range)
pH	7.395 (7.350–7.450)
pCO ₂	39.9 mmHg (35.0–48.0)
pO ₂	81.1 mmHg (83.0–108.0)
cNa ⁺	140 mmol/L (136–146)
cK ⁺	3.5 mmol/L (3.4–4.5)
cCa ²⁺	1.13 mmol/L (1.15–1.29)
cCl ⁻	111 mmol/L (98–106)
Glucose	185 mg/dL (70–105)
cHCO ₃ ⁻	23.9 mmol/L
SpO ₂ (oximetry)	95.6% (95.0–99.0)



Fig 1 Tracheal Narrowing (Pre-Procedure).



Fig 2 Serial Tracheal Dilatation.



Fig 3 Post Tracheal Dilatation.

III. DISCUSSIONS

Anaesthetic management of severe subglottic/tracheal stenosis for endoscopic dilation represents a genuine “shared airway” challenge, compounded here by three additional factors: (1) suspected concurrent tracheomalacia, which made muscle relaxation relatively contraindicated for fear of dynamic airway collapse; (2) the need to preserve a route for both ventilation and endoscopic instrumentation in a markedly narrowed lumen; and (3) the mandate for low FiO₂ due to intraoperative laser use.

Dexmedetomidine, a highly selective α_2 -adrenoceptor agonist, is particularly suited to this scenario because, unlike most sedative-hypnotic and opioid agents, it produces sedation and analgesia with comparatively preserved respiratory drive across the typical clinical dosing range, while also providing useful attenuation of airway reflexes and haemodynamic stability. Case reports describe dexmedetomidine infusions, dosed according to actual body weight, being titrated to achieve a general-anaesthetic-like state for laser destruction of severe subglottic stenosis while preserving spontaneous ventilation and avoiding the respiratory depression typically seen with other agents [4]. Similarly, dexmedetomidine sedation combined with an opioid analgesic has been used to safely secure the airway in cases of extreme tracheal narrowing while spontaneous respiration was successfully maintained throughout [2]. In the paediatric endoscopic airway surgery literature, dexmedetomidine-based total intravenous anaesthesia has similarly been favoured for tubeless, spontaneously breathing techniques, given the drive to avoid muscle relaxants and provide anaesthesia compatible with a shared, unsecured airway; total intravenous approaches have also been noted to reduce operating-room contamination with volatile agent compared with inhalational maintenance, a benefit reflected in our own case [5].

The Cotton-Myer grading system, originally described to standardise reporting of subglottic stenosis severity by relating the largest endotracheal tube passable with an air leak to age-matched normal calibres, remains the most widely used classification tool; grade III denotes 71–99% luminal obstruction, representing near-critical narrowing with very little safety margin for further compromise [1,6] — precisely the situation faced in our patient, which drove the decision to avoid muscle relaxants entirely.

Concurrent laser use imposed the additional requirement of minimising FiO₂. Reducing FiO₂ while maintaining adequate oxygen saturation is a key strategy for reducing airway fire risk, and non-intubation, spontaneously breathing techniques for laser airway surgery reduce the amount of flammable material in the airway while providing good surgical exposure, though they carry the trade-off of less precise control of ventilation [7,9]. A recent experimental study using a porcine laryngeal model found that while increasing laser power reliably shortened the time to flame onset and increased flame frequency, changes in FiO₂ alone were not a statistically significant predictor of expansive or blowtorch flame occurrence, whereas jet ventilation was

associated with a higher flame incidence than high-flow ventilation, suggesting that ventilation strategy and laser power are, at minimum, as important as FiO₂ reduction alone in mitigating fire risk, reinforcing the rationale for our combined low-FiO₂, low-flow spontaneous-ventilation approach with a supraglottic device rather than jet ventilation [8].

A comparable recently published case similarly described a young adult male who sustained traumatic injury requiring invasive mechanical ventilation and intensive care, subsequently developing severe tracheal stenosis and undergoing elective balloon tracheal dilation, with anaesthetic goals centred on avoidance of deep volatile exposure, avoidance of positive-pressure ventilation, and minimisation of postoperative respiratory complications, closely paralleling the rationale applied in our patient [10].

Overall, this case illustrates that a dexmedetomidine-based, opioid-supplemented, muscle-relaxant-free spontaneous-ventilation technique using a supraglottic airway is a feasible and effective strategy for endoscopic tracheal dilation in a patient with severe post-tracheostomy stenosis complicated by suspected tracheomalacia and the added constraint of concurrent laser use, achieving stable anaesthetic depth, preserved airway patency, satisfactory gas exchange, and reduced ambient anaesthetic gas pollution.

IV. CONCLUSION

In patients with severe subglottic/tracheal stenosis and suspected tracheomalacia undergoing endoscopic tracheal dilation with laser assistance, a total intravenous, dexmedetomidine-based technique that preserves spontaneous ventilation — avoiding neuromuscular blockade and using a supraglottic device such as the i-gel alongside low FiO₂ — offers a safe and reproducible approach that balances airway patency, anaesthetic depth, and fire-safety considerations.

➤ *Conflict of Interest*

No conflict of interest.

➤ *Funding*

None.

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