Case Report

Spontaneous ventilation as a key ventilation technique during open airway phase in tracheal resection and reconstruction: A case series

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ABSTRACT

Anaesthetic management of tracheal resection and reconstruction in patients with difficult tracheal pathologies, poses unique challenges—such as pre-operative assessment and preparation, the induction of general anaesthesia, airway sharing with surgeons during the intra-operative period while performing resection and reconstruction, emergence from general anaesthesia, and post-operative care. While there are no guidelines on choosing the ideal airway technique for the intra-operative period, we describe a simple-yet-effective airway modality, viz. spontaneous ventilation, as a key airway technique during the crucial open airway phase during tracheal reconstruction.

Key words: Open airway phase, spontaneous ventilation, tracheal resection and reconstruction

INTRODUCTION

Tracheal resection and reconstruction (TRR) is the most challenging and unique of all cases when it comes to administering anaesthesia. Providing acceptable oxygenation and ventilation along with uninterrupted surgical field while managing the open airway phase remains the keystone area demanding exceptional skills from any experienced anaesthesiologist. While there are various airway techniques to manage this crucial phase, each with their own limitations, there are no controlled randomised trials available showing the superiority of one over the other.[1-3] Here, we report a case series of four patients who were successfully managed with spontaneous ventilation during the critical open airway phase of TRR.

CASE REPORT

All four adult cases of tracheal stenosis were caused by prolonged mechanical ventilation. All of them underwent tracheostomy initially in view of post-intubation stridor and were followed up for TRR. The pre-operative evaluation revealed no co-morbidities, and systemic examination findings were normal except for the presence of tracheostomy.

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The tracheostomy tube's patency was assessed in all cases. Pre-operative indirect laryngoscopy (Karl Storz, Tuttlingen, Germany) revealed mobile vocal cords in all four patients.

In addition to standard monitoring (electrocardiogram [ECG], blood pressure, pulse oximetry, and end-tidal capnometer), neuromuscular monitoring of adductor policies, invasive blood pressure, arterial blood gas, urine output, and entropy monitoring were done in all cases. After pre-oxygenation through the tracheotomy tube, general anaesthesia was induced intravenously with fentanyl, propofol, and vecuronium. A few minutes after ventilation through the tracheostomy tube, it was replaced by a reinforced tracheal tube (TT) (Mallinckrodt, Covidien, Massachusetts, USA) through the tracheostomy stoma [Figure 1a]. Subsequently, a polyvinyl chloride (PVC) TT (Smiths medical ASD, Inc. North Minneapolis, USA) was inserted through the oral route across the vocal cords into the proximal blind end of the stenosed trachea and fixed at the angle of the mouth. Patients were then positioned for surgery with mild neck extension by placing a folded towel under the shoulder. Patients were administered sevoflurane in air-oxygen mixture with a MAC ranging from 0.8 to 1 through the reinforced TT along with timely intravenous (IV) vecuronium and fentanyl boluses during the initial tracheal dissection phase. The tracheal lesion was accessed through a transverse cervical incision. As the lesion was identified, diseased tracheal rings were excised along with the tracheal stoma. The proximally placed PVC TT was open to the surgical field after the resection of the diseased proximal trachea. Atracurium IV was given as carefully titrated doses to prepare for the next critical open airway phase. In all the four cases, the reinforced TT was removed once the patient spontaneously showed signs of adequate ventilation. The inhalational agent and muscle relaxant which was being tapered until this point was totally stopped. Oxygen at 8–12 L/min was administered through the oral endotracheal tube (ETT) to flood the field with limited use of electrocautery as the field was insufflated with oxygen.

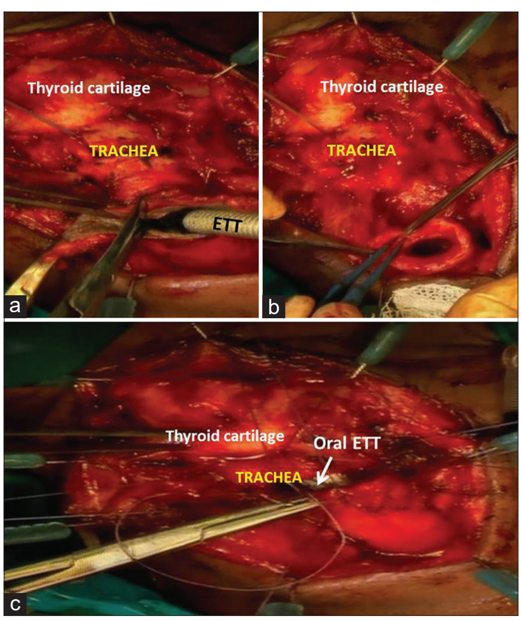

Figure 1: Surgical steps and airway management involved in upper TRR; (a) Tracheostomy tube being replaced by reinforced ETT; (b) Open airway phase; (c) Oral ETT passed beyond the surgical site after completion of posterior wall reconstruction

Intravenous dexmedetomidine was started with the recommended loading dose of 1 μg/kg over 10 min and a maintenance dose of 0.5 to 1 μg/kg. Propofol was administered at the rate of 50–200 mcg/kg/min intravenously. Both these agents were titrated to keep state entropy between 50 and 60 to maintain spontaneous ventilation. In addition, intravenous fentanyl boluses were administered to provide analgesia if necessary. Ventilation and oxygenation were monitored using ECG-derived respiration rate monitor (based on transthoracic impedance through ECG leads), the partial pressure of CO_2 ($PaCO_2$), and finger pulse oximetry. During this open airway phase [Figure 1b], patients were breathing spontaneously with variable FiO_2 provided by the oral ETT and entrained room air. The posterior wall of the trachea was reconstructed first followed by the anterior wall. Before closing the anterior wall, atracurium bolus was repeated and waited for the train of four counts to become zero. The oral ETT was then advanced through the new anastomotic site into the distal segment [Figure 1c], and the ETT cuff carefully inflated with 4% topical lignocaine to the sealing volume to improve the tube tolerance in the postoperative period until extubation.[4] In all the cases, the anterior wall reconstruction was done after advancing the PVC beyond anastomotic site. Then, the patients were ventilated with positive pressure through the oral ETT, and the inhalational agent was resumed with vecuronium until the end of the surgery. At this point, the propofol infusion was stopped. All patients were reversed from the neuromuscular blockade and extubated on table. To avoid extubation response such as coughing and bucking, IV dexmedetomidine was continued along with fentanyl boluses until the time of extubation [Figure 2]. There were no episodes of bradycardia or hypotension in any of the cases despite simultaneously infusing propofol and dexmedetomidine. All patients were assessed for possible intra-operative awareness by Brice questionnaire,[5] and none of them showed signs of recalling intra-operative events. The rest of the post-operative course was uneventful.

DISCUSSION

The complex nature of the surgical steps and airway management in TRR depends mainly on the site of the tracheal pathology. The complexity increases further when the stenosis involves the lower airway.[6] All the four cases had high cervical tracheal complete stenosis and therefore required upper TRR. This report describes a safe way to manage open airway phase during high tracheal resection and allow unhurried reconstruction of the trachea by the surgeons.

Once the proximal and distal tracheal segments are released while reconstructing the trachea, especially the posterior wall, the TT in the surgical field needs to be pulled out to enable a clear field. This open airway phase can be dealt with using various airway techniques to maintain ventilation and oxygenation. Intermittent apnoeic ventilation, high frequency positive pressure ventilation, high frequency jet ventilation, and high frequency oscillatory ventilation are the available airway modalities commonly used in open airway phase during TRR across various centres.[2] Case reports rarely demonstrated spontaneous ventilation and cardiopulmonary bypass being used as the primary measure to facilitate gas exchange.[7]

The ideal airway modality provides acceptable oxygenation and ventilation. It should, preferably, not interfere or cause the least interference with the ongoing surgical process.[4]

The advantages and limitations [Table 1] of each airway modality should be carefully considered while planning for the open airway phase. Spontaneous ventilation, one of the simplest techniques described in the literature,[2] can be achieved by carefully titrated intravenous anaesthetics, notably propofol or dexmedetomidine. In this report, we used propofol and dexmedetomidine infusion for the combined purpose of maintaining anaesthesia and supplementing analgesia, respectively. Supplemental high flow oxygen administered through the orotracheal tube fixed just

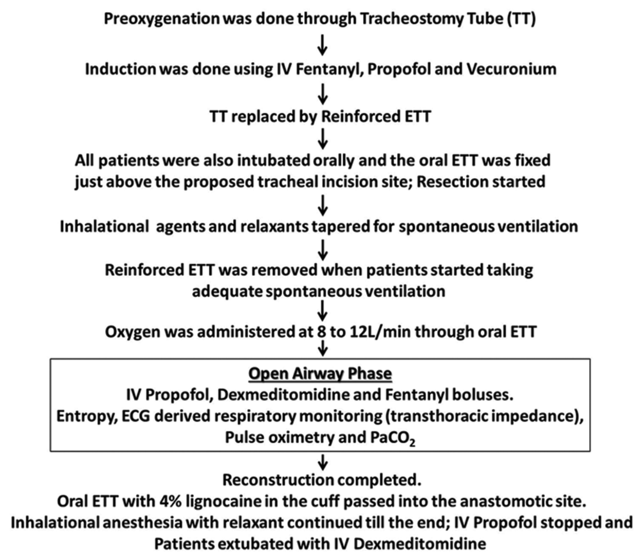

Figure 2: Flow chart demonstrating anaesthetic management of TRR in all four cases; TT: Tracheostomy Tube; ETT: Endotracheal Tube

Table 1: Advantages and limitations of available airway techniques used during open airway phase in upper tracheal resection and reconstruction

Airway techniques	Advantages	Limitations
1. Spontaneous ventilation	a. Uninterrupted and smooth surgical field. b. Better surgical access. c. Faster reconstruction.	a. Inadequate depth of anaesthesia. b. Ventilation cannot be assessed or controlled. c. Variable FiO_2. d. Inappropriate patient movement. e. High chances of coughing and bucking.
2. Intermittent positive pressure ventilation through the endotracheal tube with neuromuscular blockade (NMB)	a. Better control over ventilation and oxygenation. b. Providing reliable FiO_2. Possible to monitor FiO_2. c. Able to monitor ventilation and the depth of anaesthesia using end-tidal CO_2 and end-tidal agent concentration, respectively. d. NMB prevents inappropriate patient movements.	a. Interrupted surgical field. b. Delays surgical procedure. c. May affect the quality of reconstruction as repeated intubations at the surgical site leads to tracheal injury.
3. High frequency Ventilation: High frequency positive pressure ventilation, High frequency jet ventilation, High frequency oscillatory ventilation	a. Free access to the field of surgery. b. The presence of auto-positive end expiratory pressure may increase FRC, thereby reducing VP mismatch. c. Minimal haemodynamic disturbances.	a. Spraying of blood across the surgical field. b. The entrainment of blood and debris into the distal trachea. c. Excessive movement of the catheter tip. d. Barotrauma if the egress of the air is not assured. e. The catheter tip may get plugged with blood.

above the proximal trachea possibly maintained the arterial oxygen tension thereby avoiding the risk of hypoxaemia. Further, the surgeon should be informed about the meticulous management of surgical field by the intermittent application of suction to clear the airway and avoid lung soiling by surgical site blood and debris. In an unlikely event of desaturation, first, increase the O_2 flow to the maximum possible, and alert the surgeon. If the SpO_2 is not improving, request the surgeon to reinsert the flexible TT into the distal trachea and assist the spontaneous ventilation. The anaesthetic depth should be adjusted to maximise the spontaneous respiration to avoid further episodes of desaturation. The $PaCO_2$ was within the clinically acceptable limits in all the four cases though they were allowed to breathe with partial muscle recovery. This can be explained by the minute ventilation being sufficient enough to meet the production of CO_2 under general anaesthesia and the reduction in the dead space ventilation, as all patients were breathing through the distal tracheal stoma. With no ETT passing through the surgical field, surgeons would find it easy to anastomose and reconstruct. Thus, uninterrupted and smooth surgical field provides quality reconstruction which could possibly add on to factors reducing the risk of post-operative restenosis.

Nevertheless, the limitations of spontaneous ventilation during this critical period should not be overlooked. The most important limitation is providing the depth of anaesthesia sufficient enough to avoid sudden patient movement while allowing spontaneous ventilation. In our case, we used entropy to monitor the anaesthetic depth. Other notable limitations include variable FiO_2 and the inability to monitor the patient's ventilation status. The oxygenation status was monitored using finger pulse oximeter and PaO_2. The ventilation status was assessed using the ECG-based respiratory rate and $PaCO_2$. Arterial CO_2 tension was maintained within a range of 35–45 mmHg. When the anastomosis was complete and the orotracheal ETT was carefully replaced, the end-tidal concentration of CO_2 was within the range of 30–40 mmHg.

Therefore, spontaneous ventilation, once feared for its complications such as inappropriate patient movement, coughing and bucking due to inadequate depth of anaesthesia and gas exchange, can now be safely considered because of the available newer and better anaesthetics.

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Conflicts of interest

There are no conflicts of interest.

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