Case Report

Laryngectomy with a Tritube® and flow-controlled ventilation

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Summary

We describe the novel use of the TriTube® and Evone® ventilator (Ventinova, Eindhoven, Netherlands) to facilitate curative resection of a transglottic squamous cell carcinoma. A 43-year-old man presented with acute laryngeal and subglottic airway obstruction secondary to a stage 4 transglottic squamous cell carcinoma. The patient underwent magnetic resonance imaging followed by a diagnostic panendoscopy. It was decided that tumour resection was appropriate and a management plan was established by a multi disciplinary team. A total laryngectomy was performed. It was determined that failure of translaryngeal tracheal intubation could be rescued with emergency surgical front-of-neck airway. General anaesthesia was induced using a total intravenous anaesthesia technique, oxygenation was achieved with high-flow nasal oxygen and the airway was secured using the TriTube and flow-controlled ventilation was delivered throughout the procedure using the Evone ventilator. This avoided an awake or emergency tracheostomy, with the associated theoretical risk of tumour seeding, allowed for excellent gas exchange throughout and permitted the surgeons to maintain a closed system during much of the procedure, including during fashioning of the stoma. When traditional laryngectomy tubes are used, this process ordinarily involves multiple extubations and apnoeic periods. Furthermore, the small subglottic tube allowed intra-operative assessment of the extent of the subglottic tumour, facilitating curative en bloc resection.

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Introduction

Laryngeal surgery provides a unique challenge to the anaesthetist. The airway may be partially obstructed, the underlying pathology may make tracheal intubation challenging and airway devices may obscure the surgical field. Airway management in these patients must therefore strike a balance between keeping the patient safe and allowing the surgery to proceed as easily as possible.

For a laryngectomy, this is traditionally achieved with either a reinforced or north facing tracheal tube [1]. However, the placement of these tubes can be difficult or impossible without significant trauma. Alternatively, a tracheostomy could be performed, but this can make the subsequent laryngectomy technically more challenging and is associated with poorer oncological outcomes [2].

We elected to use the Tritube® tracheal tube (Ventinova, Eindhoven, Netherlands). This is an ultrathin tube with an external diameter of 4.4 mm (Fig. 1b). Since the inner diameter of 2.4 mm would make passive expiration impractical, it is coupled with

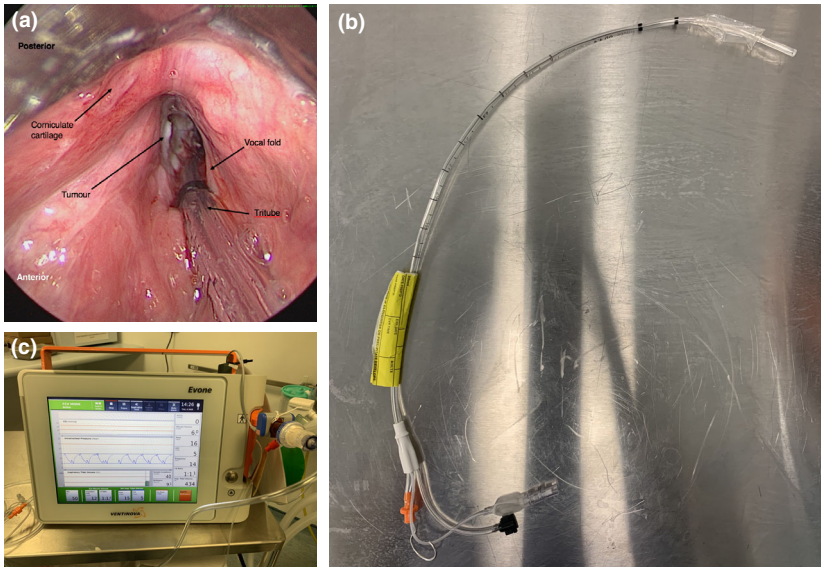

Figure 1 (a) View of the larynx with the Tritube in situ during surgical laryngoscopy. (b) Tritube. (c) Evone ventilator demonstrating the pressure trace obtained when used on a test lung.

the Evone® ventilator (Ventinova, Eindhoven, Netherlands; Fig. 1c). This uses flow control to a set peak inspiratory pressure with an inspiratory ventilation pattern similar to more traditional volume control ventilation. In expiration, it utilises a controlled negative pressure gradient to equal inspiratory volumes and prevent alveolar gas trapping [3].

Report

A 43-year-old man with a background history of childhood asthma, alcohol dependence and gastro-oesophageal reflux disease was admitted for a laryngectomy and bilateral neck dissection. He initially presented with worsening shortness of breath, dysphonia and stridor. Flexible nasendoscopy demonstrated a laryngeal mass with significant transglottic narrowing to 4–6 mm. He was taken to the operating theatre for urgent debulking. General anaesthesia was induced and maintained using a total intravenous anaesthesia technique. Supplemental oxygen was supplied during induction via trans-nasal humidified rapid-insufflation ventilatory exchange (THRIVE) at 70 $l.min^{-1}$. The patient's trachea was intubated with a 5.0-mm microlaryngeal tube. The patient was discharged with a plan to return 6 weeks later for a laryngectomy.

The patient was admitted acutely 2 days before the planned procedure due to worsening shortness of breath. Magnetic resonance imaging (MRI) demonstrated worsened airway narrowing with a minimum diameter of 2 mm. The patient reported more severe dyspnoea when lying flat and on exertion, in addition to an escalation of gastro-oesophageal reflux symptoms. He was adequately fasted for the procedure and pre-medicated with 40 mg of omeprazole and 900 mg of gabapentin.

Given the requirement for surgical access and his critically narrow airway the Evone ventilator and Tritube were used to ensure both a safe airway and optimised surgical access.

Anaesthesia with propofol and remifentanil was used for induction and maintenance of anaesthesia. Pre-oxygenation was facilitated by high-flow nasal oxygen at a flow rate of 70 $l.min^{-1}$, with the patient sitting at 45° for 10 min. Following induction of anaesthesia and administration of 100 mg rocuronium, S_pO_2 decreased from 100% to 92% at 60 s. Intubation of the patient's trachea was performed using a McGrath videolaryngoscope with a size 4 blade and a grade 1 view was obtained. The Tritube (Fig. 1a) was inserted and the stylet removed. Tracheal intubation was confirmed via viewing of misting of the tracheal tube, the presence of an end-tidal carbon dioxide ($ETCO_2$) trace and bilateral chest rise and the tracheal tube was secured. The Evone ventilator was used throughout the 7-h operation, achieving excellent gas exchange with $ETCO_2$ almost equalling $PaCO_2$ on an arterial gas taken 90 min after induction of anaesthesia ($ETCO_2$ 4.7 kPa, $PaCO_2$ 4.73 kPa).

Before proceeding to laryngectomy, the surgeons performed laryngoscopy to ensure the tumour was still amenable to resection. Of note, the surgical team had difficulty passing a 2.9-mm diameter paediatric rigid endoscope into the airway due to the tumour bulk. The Tritube did not significantly contribute to this and prevented the need to change from a microlaryngeal tube to a reinforced tracheal tube to undertake the laryngectomy.

The tumour was deemed resectable by the surgeons and a laryngectomy with bilateral neck dissection was performed. Assessment of the subglottic extent of the tumour aided the planning of the resection and ensured that adequate margins could be taken as well as improving reconstructive outcome. During formation of the tracheal stoma, the majority of the suturing was possible with the Tritube in situ due to its size and flexibility. A single brief apnoeic period was required to change to a laryngectomy tube. Normally, forming the stoma would necessitate repeatedly inserting and removing the tracheal tube.

Postoperatively the patient was transferred to the intensive care unit with a tracheostomy in situ to facilitate a controlled emergence from anaesthesia. He was then moved to the ward for ongoing postoperative care and rehabilitation. During this time, the patient had difficulty establishing adequate oral intake due to ongoing nausea but had an otherwise uneventful recovery.

Discussion

Laryngeal surgery poses significant challenges to both the anaesthetist and the surgeon. The goal is to achieve optimal surgical conditions while maintaining a safe and secure airway to facilitate adequate ventilation throughout the operation. Classically, elective laryngectomies are performed using either a north facing or reinforced tracheal tube. The Tritube is an alternative with a significantly smaller external diameter of 4.4 mm which, when paired with the Evone ventilator, provides both improved surgical access and adequate gas exchange [3]. The 6.0-mm reinforced tracheal tube in comparison is bulky with an external diameter of 8.2 mm, almost double that of the Tritube [4]. An alternative smaller external diameter tube is the 5.0-mm microlaryngeal tube with an external diameter of 6.9 mm [5]. However, the use of a microlaryngeal tube for prolonged surgeries such as a laryngectomy may not enable satisfactory ventilation and gas exchange when used with conventional ventilators. Furthermore, it has a diameter 56% greater than that of the Tritube, which in the context of the narrowed surgical field is of substantial size. A recognised limitation of the microlaryngeal tube is its tendency to obscure the posterior third of the glottis [7]. In this case, it would have prevented passage of the endoscope to assess the extent of the tumour and determine the entry point to the airway. The alternative would have involved either debulking the tumour to allow passage of a tracheal tube, or performing an awake tracheostomy before proceeding. Debulking would have, by necessity, required a tubeless field until enough of the tumour had been removed to allow passage of a tracheal tube. This would have carried high risk of airway soiling airway and seeding of the tumour. Tracheostomy, on the other hand, has the inherent risk of violating the tumour and subsequently seeding malignant cells, particularly if undertaken as an emergency. Pre-laryngectomy tracheostomy is an independent risk factor for locoregional recurrence in a salvage setting [2]. Furthermore, it forces the surgeon to fashion the new tracheal stoma below the tracheostomy. This can make it difficult to bring the remaining trachea to the skin, potentially requiring resection of the manubrium or sternum, exposing a blowout risk to the innominate vessels and impairing the functionality of the stoma for the patient.

From an anaesthetic perspective, the Tritube provided ease of insertion. Given the progressive airway narrowing demonstrated on repeat MRI at 6 weeks despite earlier debulking, tracheal intubation with the relatively inflexible standard 5.0-mm microlaryngeal tube would have posed a high risk of difficult insertion and resultant trauma. The Tritube, which is inserted using a stylet, provides superior flexibility coupled with a smaller external diameter. Consequently, it was able to pass through the transglottic narrowing without causing any obvious bleeding or trauma.

A further consideration when using a microralyngeal tube in combination with conventional ventilation is the higher driving pressures required due to the high resistance to airflow which results in overall higher airway pressures. Furthermore, as a result of the small internal diameter, carbon dioxide clearance can be problematic. Longer inspiratory:expiratory (I:E) ratios are typically utilised to allow for complete expiration and effective gas exchange [6]. To overcome the limits of passive expiration through the narrow lumen of the Tritube, the accompanying Evone ventilator uses a proprietary technique called flow-controlled ventilation. This creates a negative pressure gradient during expiration to actively generate a consistent and controllable flow rate. This active expiration allows ventilation to continue without gas trapping even at the manufacturer-recommended I:E ratio of 1:1 [7]. Together with the relatively small deadspace of the system, this explains the reason why ET CO_2 and $PaCO_2$ were so evenly matched in this case.

An alternative ventilation technique that could be considered in the context of the narrowed airway is high-frequency jet ventilation. Both bleeding and distal seeding are recognised complications of this technique. Moreover, jet ventilation can cause significant movement of the cords which increases surgical risk [8]. Despite the ability to provide reasonable ventilation during tumour debulking, there are a number of other complications including risk of gastric insufflation if used supraglottically, drying of the airway due to lack of humification and barotrauma. The Tritube and Evone reduce all of these risks particularly that of gastric content aspiration which may be catastrophic in the context of uncontrolled gastro-oesophageal reflux.

Overall the use of the Tritube presents the potential to mitigate the need for debulking with an unsecured airway before total laryngectomy. Airway protection can be maintained for the duration of the operation with minimal compromise to the surgical field view. The tube permits the endoscopic assessment of subglottic and tracheal cancers aiding the safe en bloc resection of tumour. Furthermore, there is potential avoidance of tracheostomy into a contaminated abnormal airway which scould compromise oncological outcome. This case demonstrates the capability of the Evone® ventilator in providing both satisfactory carbon dioxide monitoring and clearance. We have now used this technique on six further cases where the airway was too narrow for a microlaryngeal tube and would previously have required a tubeless airway technique. This has facilitated debulking of the tumours in each case while minimising risk to the patient.

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References

1. Stephens M, Montgomery J, Urquhart CS. Management of elective laryngectomy. *British Journal of Anaesthesia Education* 2017; **17**: 306–11.
2. Birkeland AC, Rosko AJ, Beesley L, et al. Preoperative tracheostomy is associated with poor disease free survival in recurrent laryngeal cancer. *Otolaryngology - Head and Neck Surgery* 2017; **157**: 432–8.
3. Ventinova Medical. Tritube, 2020. https://www.ventinovamedical.com/tritube/ (accessed 14/10/2020).
4. Medtronic. Solutions for all your airway needs. page 12, 2020. https://www.medtronic.com/content/dam/covidien/library/emea/en/product/tracheostomy/weu-airway-management-product-catalogue.pdf (accessed 14/10/2020).
5. Medtronic. Solutions for all your airway needs. page 11, 2020. https://www.medtronic.com/content/dam/covidien/library/emea/en/product/tracheostomy/weu-airway-management-product-catalogue.pdf (accessed 14/10/2020).
6. Pearson KL, McGuire BE. Anaesthesia for laryngo-tracheal surgery, including tubeless field techniques. *British Journal of Anaesthesia Education* 2017; **17**: 242–8.
7. Ventinova Medical. Concept, 2020. https://www.ventinovamedical.com/concept/ (accessed 14/10/2020).
8. English J, Norris A, Bedforth N. Anaesthesia for airway surgery. *British Journal of Anaesthesia Education* 2006; **6**: 28–31.

