# Apnoeic Oxygenation with High-Flow Oxygen for Tracheal Resection and Reconstruction Surgery

**Nguyen Minh Ly**
108 Military Central Hospital
**Ngo Van Dinh**
108 Military Central Hospital
**Dinh Thi Thu Trang**
108 Military Central Hospital
**Ngo Vi Hai**
108 Military Central Hospital
**Tong Xuan Hung** (txhung108@gmail.com)
108 Military Central Hospital

**Research Article**

**Keywords:** Tracheal resection, Reconstruction, Stenosis, Anesthesia, High-flow, Apnoeic oxygenation.

**Posted Date:** June 7th, 2021

**DOI:** https://doi.org/10.21203/rs.3.rs-590516/v1



**Version of Record:** A version of this preprint was published at BMC Anesthesiology on March 18th, 2022. See the published version at https://doi.org/10.1186/s12871-022-01610-y.

# Abstract

**Background:** Tracheal resection and reconstruction are the most effective treatment tracheal stenosis, but the difficulties are surgery and maintaining ventilation performed on the patient's same airway. High-flow oxygen has begun to be applied prolonging the apnoea time in the tracheal anastomosis period for tracheal resection and reconstruction. This study aims to evaluate the effectiveness of apnoeic conditions with high-flow oxygen as the sole method of gas exchange during anastomosis construction.

**Methods**: A prospective study was performed on 16 patients with tracheal stenosis, with ages ranging from 19 to 70, underwent tracheal resection and reconstruction from April 2019 to August 2020 in 108 Military Central Hospital. During the anastomosis phase using high flow oxygen of 35-40 L/min delivered across the open tracheal with an endotracheal tube (ETT) at the glottis in apnoeic conditions.

**Results:** The mean (SD) apnoea time was 20.91 (2.53) mins. Mean (SD) time anastomosis was 22.9 (2.41) mins. The saturation of oxygen was stable during all procedures at 98-100%. Arterial blood gas analysis showed mean (SD) was hypercapnia and acidosis acute respiratory after 10 mins of apnoea and 20 mins apnoea respectively. However, after 15 mins of ventilation, the parameters are ultimately returned to normal. All 16 patients were extubated early and safely at the end of the operation. There were no complications, such as bleeding, hemothorax, pneumothorax, or barotrauma.

**Conclusion:** High-flow oxygen across the open tracheal under apnoeic conditions can provide a satisfactory gas exchange to allow tubeless anesthesia for tracheal resection and reconstruction.

# Background

Tracheal stenosis is a rare disease often caused by prolonged intubation, primary or secondary tumors, and invasive thyroid cancer. They are life-threatening if not adequately treated [1]. Tracheal resection and reconstruction are the most effective treatment, but the difficulties are surgery and maintaining ventilation performed on the patient's same airway.

Depending on the severity and location of the stenosis and the type of surgical procedure, there may be a variety of choices for perioperative airway management such as a facemask, laryngeal mask airway, tracheal intubation tube, jet ventilation with the small catheter, cardiopulmonary bypass, and extracorporeal membrane oxygenation [9], [13], [14], [17], [19], [20].

The methods like intubation or using small-sized high-frequency catheters often cause a narrow surgical field and limited vision.

Recently, high-flow nasal and high-flow oxygen delivery device attached directly to a laryngeal mask or tracheal tube has begun to be applied to provide oxygen for some laryngeal surgery without intubation as well as prolonging the apnoea time in the difficult intubation [2], [4], [7], [8], [10], [11].

We also applied this method during the tracheal anastomosis period for tracheal resection and reconstruction, aiming to create an optimal surgical field without endotracheal intubation and ventilation.

This study aimed to evaluate the gas exchange efficiency and safety of apnoeic oxygenation with a high-flow oxygen method, used for airway management at 16 patients tracheal resection and reconstruction.

## Methods

From April 2019 to August 2020, 16 patients were diagnosed with tracheal stenosis caused by cancer invasive thyroid cancer, tracheal stenosis after intubation, and upper tracheal tumor. They were scheduled for tracheal resection and reconstruction surgery using high-flow oxygen combined for airway management at the Department of Anesthesia of 108 Military Central Hospital.

# Preoperative preparation and materials

The equipment and anesthesia agents:

- Anesthesia machine, multi-parameter monitor, TCI (target-controlled infusion) system.
- Fibroscope, rigid bronchoscope
- High-flow oxygen system
- Flexible endotracheal tubes (ETT), ID sizes from 4.0 to 7.5. The Proseal laryngeal mask size 3–5. Catheters with diameters of 3.3–4.7 mm (Cook Airway Exchange Catheter) can pass through narrow positions for high-frequency jet ventilation.
- Anesthesia agents: Propofol, rocuronium, fentanyl, morphine.
- Emergency instruments.

# Evaluation of patients:

Evaluation of patients includes general history and physical examination, with particular attention to the airway and pulmonary systems, and analyzing arterial blood gases.

To prepare for any possible airway emergency during the induction and maintenance of anesthesia, it is essential to carefully evaluate the stenosis or tumor's exact location and the obstruction degree preoperatively.

Magnetic resonance imaging scans provide greatest diameter of the tracheal stenosis or tumor, minimum tracheal diameter, the length of the lesion, the distal from the vocal cord to the tracheal stenosis, from stenosis to the carina…

Bronchoscopy defines the character of the tracheal stenosis or tumor surrounding tracheal by a direct vision that can be predicted capacity intubated and operated.

# Method

Before the induction, it must be considered that spontaneous breathing or mechanical ventilation is likely to be possible through the stenosis with general anesthesia. Nevertheless, severe airway obstruction may occur during the induction of general anesthesia, and thus the appropriate backup method will be required to prevent disaster.

The surgeon should always be in the OR during induction and available to manage a surgical airway if this becomes necessary. A rigid bronchoscope, transtracheal jet ventilation (TTJV) must be immediately available.

If possible, mask ventilation under general anesthesia, preoxygenation with 6 l.min-1 100% for 5 mins, slow and gentle induction of anesthesia following by intravenous fentanyl 2 μg/kg, propofol TCI Cp 3.5-4 μg/ml, rocuronium 0.6 mg/kg.

The positive pressure ventilation was secured via facemask, inserting the endotracheal tube into the tracheal so that the tip of the endotracheal tube is close to the stenosis if the distance from the vocal cord to the lesion > 2 cm. If mild tracheal stenosis, we use tube 5.0–6.0 Fr passed through the narrow position.

If the distance from the vocal cord to the lesion very short < 2 cm, the Proseal laryngeal mask (LMAP) is placed, inserted sonde gastric through the second tube of LMAP, continuous ventilation via LMAP.

If the patient has severe stenosis and airway obstruction, we use catheters with diameters of 3.3–4.7 mm. (Cook Airway Exchange Catheter) put through narrow positions for high -frequency jet ventilation with 100% oxygen.

In case the patient has a tracheostomy, ventilating through the tube of tracheostomy.

Anesthesia was maintained intravenously by the combination of propofol using Target Controlled Infusion (TCI) method 3.5-4 μg/ml, fentanyl 2–3 μg /kg/h, rocuronium 0.2 mg/kg/h, methylprednisolone 2 mg/kg.

Once the airway is opened, the surgeon inserts a flexible endotracheal tube 6.5–7.5 Fr into the distal airway and ventilates. They were completely removing the laryngeal mask, endotracheal tube, catheter Cook. Setting a waiting endotracheal tube at glottis and connecting to the high-flow oxygen system with FiO2 100%.

Once the tracheal lesion is removed, and the surgeon starts anastomosis, open the oxygen flow 35–40 l.min-1 so that the oxygen is provided across the open trachea. Adjust for the direction of oxygen flow straight to the distant tracheal. During this period, the patient is still under general anesthesia, neuromuscular blocking agents, and stops breathing completely. SpO2 and arterial blood gases were monitored. If SpO2 drops < 90%, ventilation supports 100% oxygen with an endotracheal tube at the tracheal distance. When the tracheal is nearly closed, push the endotracheal tube so that the cuff passes over the anastomosis and normalizes the ventilation.

End of surgery: Extubation is the primary goal because postoperative mechanical ventilation is associated with anastomotic failure; the reconstructed airway may be tenuous. When the patients awake and cooperative, all vital parameters were normal limits; patients should be extubated on the table as soon as possible

### Monitoring and evaluation criteria

- Characteristics of the patients: Age, height, body weight, classification of dyspnea according to MMRC (Modified Medical Research Council), degree of the physical state of the patients ASA (American Society of Anesthesiologists). Degree of tracheal stenosis according to Cotton- Mayer
- Surgical characteristics: Anesthesia time, surgery time
- The method of maintaining ventilation.
- The anastomosis time: from the tracheal open to the end closed airway.
- Apnoeic time using high flow
- The vital parameters were monitored continuously: Heart rate, $SpO_2$, $EtCO_2$, Blood pressure. All results are expressed as mean ± SD, blood gases analysis (ABG) at 5 periods: T0: Before the anesthesia; T1: Before using high flow. T2: After using high-flow 10 mins; T3: After using high-flow 20 mins and T4: 15 mins after high-flow finishes.

The complications in surgery include airway obstruction, tumor peeling, gas overflow, pneumothorax.

## Results

The mean age of the group was 46.50 ± 16.42 years. The proportion of males in the group (56.25%) was higher than females (43.75%). Most patients were ASA III, 02 patients were ASA IV, who have life-threatening dyspnea requiring emergency surgery (Table 1). The cause of tracheal stenosis, classification of dyspnea, and degree of tracheal stenosis were shown in Table 2,3,4. The average of apnoea time was 20.91 ± 2.53 mins that’s mean the time enough for anastomosis. Additional information shown in Table 5.

Table 1
Characteristics of the patients

| Age (years) ± SD<br>Min-Max | Height(cm)<br>± SD<br>Min-Max | Weight(kg)<br>± SD<br>Min-Max | Gender | | ASA | | |
|---|---|---|---|---|---|---|---|
| | | | Male<br>n(%) | Female<br>n(%) | II<br>n(%) | III<br>n(%) | IV<br>n(%) |
| 46.50 ± 16.42<br>19–70 | 160.06 ± 5.16<br>152–168 | 50.50 ± 3.39<br>43–55 | 09(56.25) | 07(43.75) | 06(37.5) | 08 (50) | 02(12.5) |

Table 2
Cause of tracheal stenosis

| Causes | Number of patients (n) | Percentage % |
|---|---|---|
| After prolong intubaion | 09 | 56.25 |
| After tracheotomy | 02 | 12.5 |
| Tracheal tumour | 01 | 6.25 |
| Thyroid cancer invasion | 04 | 25 |
| Total | 16 | 100 |

Table 3
Classification of dyspnea (Modified Medical Research Council)

| *Dyspnea scale* | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Total |
|---|---|---|---|---|---|
| n | 3 | 6 | 5 | 2 | 16 |
| % | 18.75 | 37.5 | 31.25 | 12.5 | 100 |

Table 4
Degree of tracheal stenosis according to Cotton- Mayer

| Degree of tracheal stenosis (%) | Number of patients | Percentage % |
|---|---|---|
| Grade 1: luminal narrowing < 50% | 03 | 18.75 |
| Grade 2: luminal narrowing ≥ 51 and < 71% | 06 | 37.5 |
| Grade 3: luminal narrowing ≥ 71% and < 99% | 05 | 31.25 |
| Grade 4: luminal narrowing ≥ 99 % | 02 | 12.5 |
| Total | 16 | 100 |

Table 5
Surgical characteristics

| Time (mins) | Min- Max | Value ± SD |
|---|---|---|
| Duration of anesthesia | 115–220 | 170.69 ± 31.89 |
| Duration of surgery | 95–185 | 134.56 ± 21.18 |
| Duration of anastomosis | 17–28 | 22.9 ± 2.41 |
| Oxygen high-flow (apnoea time) | 16–28 | 20.91 ± 2.53 |

There may be a variety of choices for perioperative airway management. In the research, there was one patient with hypoxia who must use high-flow oxygen combined ventilation intermittent through endotracheal tubes at the distant tracheal (Table 6). During the period high-flow (T2, T3), PaO2 improved significantly compared to the time of T0; acute respiratory acidosis clearly showed pH decreased, PaCO2 and HCO3- increased. However, these data return to normal at the time of T4 (Table 7 and Fig. 1). Heat rate and MAP after high-flow oxygen was decreased significantly compared with T0 (before induction), SpO2 at T0 was significantly lower than T1, T2, T3. After 20 mins of high flow (T3), etCO2 was significantly higher than before and after using high-flow oxygen (Table 8).

Table 6
Airway management

| Period | Methods | Number of patients | Percentage % | Total |
|---|---|---|---|---|
| Induction ( before dissection) | Intubation above the lesion | 04 | 25 | 100% |
| | Intubation through the lesion | 06 | 37.5 | |
| | Laryngeal mask | 03 | 18.75 | |
| | At tracheostomy | 02 | 12.5 | |
| | The Small catheter for jet ventilation | 01 | 6.25 | |
| Open airway (Anastomosis) | High-flow oxygen single | 15 | 93.75 | 100% |
| | High-flow oxygen combined ventilation intermittent | 01 | 6.25 | |

Table 7
Arterial blood gas exchange data

| Time<br>Data | T0<br>± SD | T1<br>± SD | T2<br>± SD | T3<br>± SD | T4<br>± SD |
|---|---|---|---|---|---|
| pH | 7.42 ± 0.02 | 7.42 ± 0.06 | 7.25 ± 0.04* | 7.17 ± 0.05* | 7.41 ± 0.06 |
| $PaCO_2$ (mmHg) | 35.95 ± 3.32 | 42.17 ± 9.63 | 67.57 ± 14.71* | 79.63 ± 13.39* | 39.48 ± 5.17 |
| $PaO_2$ (mmHg) | 101.1 ± 3.54 | 220.38 ± 62.08* | 167.12 ± 76.23* | 186.19 ± 60.14* | 217.63 ± 74.63* |
| Lactat | 1.0 ± 0.42 | 1.16 ± 0,51 | 1.06 ± 0.6 | 1.06 ± 00.58 | 1.26 ± 0.87 |
| $HCO_3^-$(mEq/L) | 23.35 ± 3.75 | 27.34 ± 5.45 | 29.79 ± 6.73* | 30.03 ± 5.5* | 25.98 ± 4.78 |
| BE (mEq/L) | 2.4 ± 0.99 | 4.57 ± 6.32 | 3.23 ± 6.08 | 2.91 ± 5.31 | 2.22 ± 4.99 |

Table 8
Change of respiratory and hemodynamic

| Time<br>Data | T0<br>± SD | T1<br>± SD | T2<br>± SD | T3<br>± SD | T4<br>± SD |
|---|---|---|---|---|---|
| Heat rate *(beat/min)* | 87.3 ± 7.5 | 76.58 ± 3.42 | 78.5 ± 4.89 | 79.17 ± 6.19 | 77.17 ± 5.62 |
| MAP*(mmHg)* | 85 ± 12 | 74.5 ± 3.78 | 74.33 ± 5.14 | 75.42 ± 6,43 | 77.16 ± 3.76 |
| $SpO_2$ (%) | 94 ± 3.7 | 99.83 ± 0.58* | 99.17 ± 1.11* | 99.67 ± 0.49* | 99.66 ± 0.65* |
| $EtCO_2$ *(mmHg)* | | 35.67 ± 3.39 | | 55.4 ± 7.16 ┼ | 33.58 ± 2.78 |
| ** p < 0.05 compared with T0;* ┼ p < 0,05*compared with T1* | | | | | |

Side effects (Table 9) in surgery were acute respiratory acidosis in all 16 patients, 01 patients with hypoxia. There were no complications of arrhythmia, pneumothorax, hemothorax, pulmonary barotrauma.

Table 9
Side effects

| Complications | Number of patients (n) | Percentage % |
|---|---|---|
| Acute respiratory distress ($PaO2 < 60$, $SpO2 < 90$) | 1 | 6.25 |
| Acute respiratory acidosis ($PaCO2 > 50mmHg$) | 16 | 100 |
| Respiratory obstruction | 0 | 0 |
| Arrhythmia | 0 | 0 |
| Pneumothorax, hemothorax, pulmonary barotrauma | 0 | 0 |

# Discussion

The course of anesthesia was divided into five phases. First: induction and intubation, a critical period. Second: dissection, a period of relative calm during which lesion is defined. Third: open airway, a crucial period in which anastomosis is being constructed. Fourth: closure and emergence and fifth: extubation [9], [16], [18].

Most of the patients with narrow airways admission to hospital due to shortness of breath, there are 03 cases of patients who can not lie, 02 cases of life-threatening who have to do the emergency surgery.

Induction is a critical period that needs to combine many flexible methods to control ventilation. The results in Table 5 show that depending on the severity and location of the stenosis, there may be various choices for airway management in the period of induction. The endotracheal tube may be placed above (25 %) or through the lesion (37.5 %), there are 3 patients (18.75 %) showing the distance from the vocal cord to the lesion very short (< 2 cm). We had to use a laryngeal mask (LMAP). It is an effective solution in the first phase.

Patients with severe tracheal stenosis > 90% with a high risk of airway obstruction ensure safety Bricker DL [3]; C.L Chiu [5], CHEN Hai-hong [17] applied the method of cardiopulmonary bypass. Although it is an easy way to ensure gas exchange, systemic anticoagulation theoretically increases bleeding risk, especially if the dissection is extensive, and lung manipulation is unavoidable.

Before the induction, we prepared all emergency equipment to prevent tracheal obstruction. Small-sized catheters to pass through the narrow for jet ventilation, surgeons, as well as surgical facilities, are prepared for tracheotomy. In 2 of our patients with tracheal stenosis > 90%, 01 patients can be intubated and ventilated above the narrow space. For the other, we had to use a small jet catheter pushed through the stenosis for jet ventilation with oxygen pure 100% before the open airway phase.

The open airway phase is a critical period in which anastomosis is being constructed. Once the airway is opened, a flexible endotracheal tube 6.5–7.5 Fr was inserted to the distal airway and ventilated, waiting for ET through the glottis and connected to the high-flow oxygen system. When the surgeon started anastomosis, open the oxygen flow 35–40 l.min-1 so that the oxygen is provided across the surgical field to the distant trachea. The time for apnoeic oxygenation or the time of anastomosis was 16–28 mins, but this time depends on the surgeon's experience. If the apnoea time is too long, which can lead to unsafety like hypercapnia or hypoxia ($SpO_2 < 90\%$, blood $pH < 7.1$)

In the period of anastomosis being constructed 10 and 20 mins (T2, T3), with high flow oxygen 35–40 l.min-1, the blood oxygen pressure improved significantly compared to the time of T0 with $PaO_2 > 170$ mmHg. The acute respiratory acidosis present, the lowest at T3 with pH was $7.17 \pm 0.05$, and $PaCO_2$ was $79.63 \pm 13.39$ $HCO_3^-$ increased significantly but returned to normal immediately after 15 mins mechanical ventilation at T4.

Tracheal resection and reconstruction require the anesthesiologist and the surgeon to share the airway. The greatest benefit of high flow is creating a free surgical field, optimal conditions for anastomosis, and no interruption of surgery without endotracheal intubation and ventilation [7]

Apnoeic oxygenation is the ability to oxygenate a patient in the absence of lung movement. At the onset of apnoea, there is a continued transfer of oxygen from the alveolus to the blood in order to fulfill the metabolic demands of the body. This oxygen transfer leads to emptying of alveoli and a fall in alveolar pressure, which is initially compensated for by reducing alveolar volume from elastic recoil and by carbon dioxide movement from blood to the alveolus. These compensatory mechanisms are rapidly exhausted, and a pressure gradient develops for oxygenation between the upper airway and the alveolus [4], [11], [12].

M Egan and et al also applied oxygen 100% at a flow-rate of 40 l.min-1 delivered across an open trachea in an apnoeic female patient with subglottic tracheal stenosis. This permitted 42 mins of uninterrupted surgery; oxygen saturations remained above 96% during the apnoeic period and arterial blood gas parameters within acceptable limits. No urgent interruption of surgery or rescue mechanical ventilation was required [4], [7].

Lyons; M. Callaghan et al applied the study between November 2016 and May 2017. 28 patients underwent tubeless laryngeal or tracheal surgery under apnoeic conditions with high-flow nasal oxygen. The median apnoea time was 19 (15–24) mins. Four patients experienced a transient episode of oxygen desaturation to a value between 85% and 90%. The partial pressure of carbon dioxide ($PaCO_2$) of 6.29 (0.71) kPa at baseline and 9.44 (1.12) kPa after 15 min of apnoea. The authors concluded that high-flow nasal oxygen under apnoeic conditions could provide a satisfactory gas exchange to allow tubeless anesthesia for laryngeal surgery [4].

The safe breathing time was calculated from the time when the patient stopped breathing until $SaO_2$ decreased < 90%. Alveoli will continue to take up oxygen even without diaphragmatic movements or lung expansion. In a healthy apnoeic patient, ~ 200–250 ml /min oxygen will move from the alveoli into the bloodstream, only 8–20 ml/min of carbon dioxide moves into the alveoli during apnoea, with the remainder being buffered in the bloodstream given the high water solubility of $CO_2$. In healthy people under ideal circumstances, PaO2 can be maintained at > 100 mmHg for up to 100 mins without a single breath. However, the lack of ventilation will eventually cause marked hypercapnia and significant acidosis, many authors have demonstrated that acute respiratory acidosis within pH > 7.15 is the safety limits are acceptable in the absence of contraindications [6], [7], [12].

The results of Tables 8 and 9 showed that during procedure hemodynamics, oxygen pressure, oxygen saturation (SpO2) were within normal limits. Only 1 patient with hypoxia during surgery is the case of patients with pneumonia in the right lower lobe should support oxygen through the distant airway.

High-flow oxygen under apnoeic conditions can provide a satisfactory gas exchange with gas exchange data improved than before surgery. The surgical field is especially completely spacious, optimal conditions for anastomosis, and no interruption of operation without endotracheal intubation.

# Conclusion

High-flow oxygen across the open tracheal under apnoeic conditions can provide a satisfactory gas exchange to allow tubeless anesthesia for tracheal resection and reconstruction. The surgical field is ultimately in spacious, optimal conditions for anastomosis. There were no complications of arrhythmia, pneumothorax, hemothorax, pulmonary barotrauma.

# Abbreviations

ETT
endotracheal tube
TCI
target-controlled infusion
TTJV
transtracheal jet ventilation
LMAP
proseal laryngeal mask
MMRC
Modified Medical Research Council
ASA
American Society of Anesthesiologists

# Declarations

## Ethics approval and consent to participate

The research was conducted following the guidelines and approval of 108 Military Central Hospital Clinical Researches Ethics Committee under the approval number 28/QĐ-BVTWQĐ108. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013. Written informed consent was obtained from all the participants of the work.

### Consent to publish

Not applicable

### Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no conflicts of interest regarding the content of this article.


### Funding

None.


### Author contribution:

All authors made a significant contribution to the work reported, whether that is in the conception, study design: NML, execution, acquisition of data: TXH, NVH, analysis and interpretation: NVD, DTTT; All authors took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All authors read and approved the final manuscript.


### Acknowledgements.

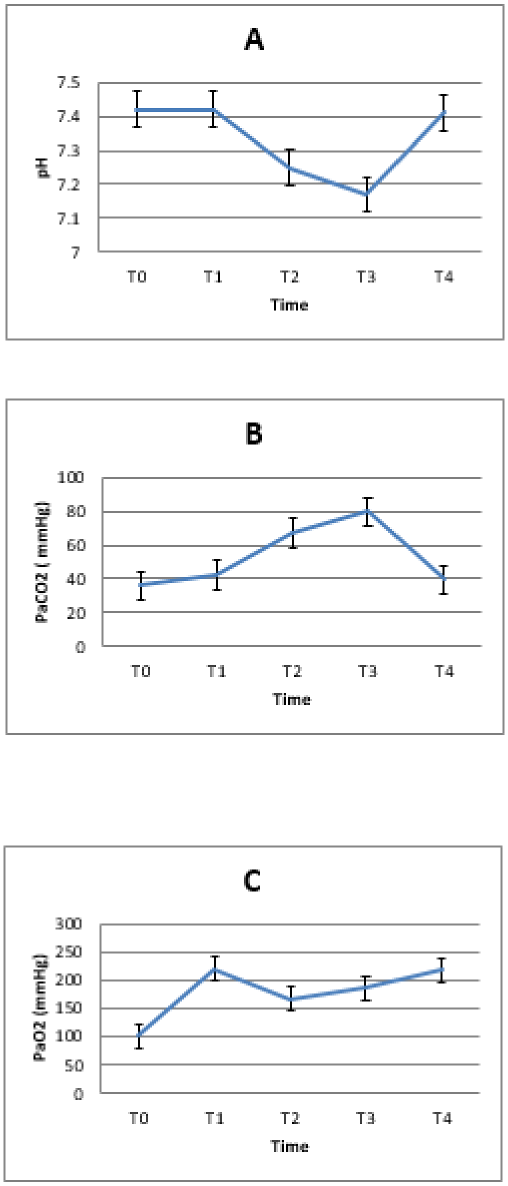
Declared none.


## References


1. Alpay Sarper MD, Arife Ayten MD, Irfan Eser MD, et al. Tracheal stenosis after tracheostomy or intubation. Tex Heart Inst J. 2005;32(2):154–8.
2. Binks MJ, Holyoak RS, Melhuish TM. *Apnoeic oxygenation during intubation in the intensive care unit*: A systematic review and meta-analysis. Heart lung: the journal of critical care;. 2017;46(6):452–7.
3. Bricker DL, Parker TM, Dalton ML. Cardiopulmonary bypass in the anesthetic management of resection. Its use for severe tracheal stenosis. Arch Surg. 1979;114(7):847–9.
4. Lyons C; M.Callanghan (2017). *Apnoeic oxygenation with high-flow nasal oxygen for laryngeal surgery: a case series*. Anesthesia, perioperative medicine, critical care and pain; Volume72, Issue11. Pages 1379–1387.

5. Chiu CL, Teh BT, Wang CY. (2003). Temporary cardiopulmonary bypass and isolated lung ventilation for tracheal stenosis and reconstruction. BrJ Anaesth; 91 (5): 742–4.
6. Chris Nickson. (2019). *Apnoeic oxygenation*. https://litfl.com/apnoeic-oxygenation/.
7. Egan M, Pro Karen C, Redmond. (2018). High flow apnoeic ventilation delivered by LMA or ETT (LMET Flow) for tracheal resection and reconstruction surgery. Anesthesia Report; Vol. 6, 1, pp. 25–9.
8. Oliveira JE, Silva L, Cabrera D, Barrionuevo P. Effectiveness of Apneic Oxygenation During Intubation: A Systematic Review and Meta-Analysis. Annals of emergency medicine;. 2017;70(4):483–94. e11.
9. Sandberg WMD, PhD (2000). Anesthesia and Airway Management for Tracheal Resection and Reconstruction, Thoracic Anesthesia; Vol. 38(1), pp. 55–75.
10. White LD, Melhuish TM, White LK, Wallace LA. Apnoeic oxygenation during intubation: a systematic review and meta-analysis. Anaesthesia intensive Scare. 2017;45(1):21–7.
11. Kim HJ, Takashi Asai. High-flow nasal oxygenation for anesthetic management. Korean J Anesthesiol. 2019;72(6):527–47.
12. Masaji Nishimura. High-Flow Nasal Cannula Oxygen Therapy in Adults: Physiological Benefits, Indication, Clinical Benefits, and Adverse Effects. Respiratory Care April. 2016;61(4):529–41.
13. Bouaggad AMD, Bennani, Fahd MD, Rachid MD, et al (2006). *Anesthesia for a patient with Tracheal Tumor using laryngel Mask airway*. Anesthesia and Analgesia; Volume 103- Issue1. pp. 258–259.
14. Deepa Kane S, Dave RS, Thota P, Pawar LV Dewoolkar (2008). *Tracheal Tumor Resection- Anesthesia Management*, Bombay Hospital Journal; Vol.50, No.1, 2008.
15. Divatia JV, Sareen R, Upadhye SM, et al, (1994). *Anaesthesia management or tracheal surgery using the laryn mask airway*, Anaesth Intensive Care; 22, pp. 69–73.
16. Celine Pinsonneault BSc MD FRCPC., Joanne Forter MDFRCPC, Francois Donati PhD MD (1999), *Tracheal Resection and Recontruction*, Can J Anaesth'; 46(5), pp. 439–455.
17. Hai-hong CHEN, Wei PAN. AN Xiao- xia (2005), *Resection of tracheal tumor under cardiopulmonary bypass: a case report*, Chinese Medical Journal; *2005, ol.118 No.12: 1047–1049.*.
18. Kazumori K. Safe method of tracheal extubation after tracheal recontruction. Journal of anesthesia. 1997;11(2):171.
19. Lennart Magnusson MD, Florian JWLang MD, Philippe Monnier MD, Patrick Ravussin MD. Anesthesia for Tracheal Resection Report of 17 cases. Can J Anaesth. 1997;44(12):1282–5.
20. Spyros D. Mentzelopoulos MD, Constantina N, Romana MD, Antoni G, Hatzimicalis MD, Maria J, Tzoufi MD. (1999), *Anesthesia for Trachael Resection: A New Technique of Airway Management in a Patient with Severe Stenosis of the Midtrachea*, Anesth Analg; 89: 1156.

# Figures




## Figure 1

( A) pH, (B) partial pressure of arterial carbon dioxide (PaCO2) and (C) partial pressure of arterial oxygen (PaO2) at T0: Before anesthesia; T1: Before using high flow. T2: After using high flow 10 mins; T3: After 20 mins of high flow and T4: Finish the high-flow 15 mins.