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Anesthetic Management of Subglottic Stenosis Procedures using High Flow Nasal Oxygen (HFNO)

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Abstract

High flow nasal oxygenation recently emerged as a technique for providing surgical field free from anesthetic airway devices. HFNO is used for pre oxygenation as well as sustained apneic oxygenation in patients with difficult airways undergoing airway surgeries. Moreover, it provides improved surgical field view and better accessibility compared to standard anesthetic technique. Here we discuss the clinical application and advantages of using HFNO as well as our institutional practice in utilizing HFNO in subglottic stenosis procedures.Airway management during endoscopic treatment of airway stenosis can be managed either with intermittent apnea, spontaneous ventilation through facemask or repeated endotracheal intubations between brief treatment intervals.

Keywords: High flow nasal oxygen • Subglottic stenosis • High flow nasal cannula • Anesthesiologist

Introduction

Subglottic stenosis is a poorly explained progressive obstruction of the airway characterized by mucosal inflammation and localized fibrosis. These patients often require multiple procedures following initial diagnosis due to high recurrence. This condition can be managed in a variety of ways but are generally categorised into:

- Endoscopic dilation of the stenosis (rigid instruments or inflatable balloon).
- Endoscopic resection of the stenosis.
- Open surgery with resection and end to end anastomosis of the tracheal segments [1].

Case Presentation

However, this approach increases the operating time due to frequent surgical interruptions as well as the airway control may be tenuous as adequate size endotracheal tube may not be possible in moderate or severe subglottic stenosis. Jet ventilation can be utilized in more difficult or severely stenotic airway but carries a risk of pneumothorax and hypoxemia if stenosis block adequate ventilator exchange [2,3]. Apneic oxygenation and ventilation using High Flow Nasal Cannula (HFNC) is an alternative and simple technique for short laryngeal procedures.

High Flow Nasal Cannula (HFNC)

High Flow Nasal Cannula(HFNC) has been used to deliver heated and humidified medical gas at flows up to 70 litres/min, using air/oxygen bender, active humidifier, single heated tube and nasal cannula (Figure 1) [4].

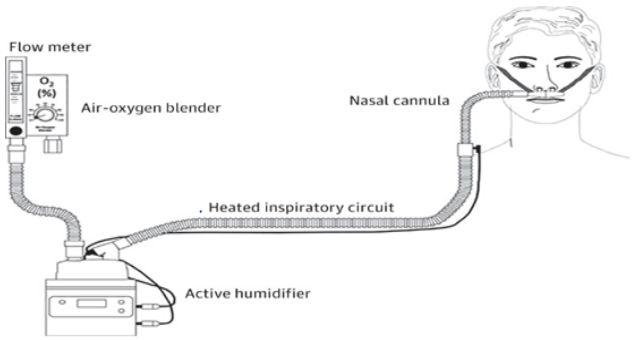

Figure 1. Single heated tube and nasal cannula.

Mechanism of action

The exact mechanism of oxygenation and ventilation with HFNO is still under investigation, however several physiological benefits have already been demonstrated. It provides inspired gas with a relative humidity of 100% which effectively prevents complications related to dryness of nasal mucosa. It delivers higher FiO_2 compared to face mask due to high flow resulting in less entrainment of ambient air. HFNC increase the mean airway pressure and creates continuous positive airway pressure [5].

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HFNO operating room applications

HFNO is used to improve preoxygenation prior to intubation, increase the apneic window in difficult intubations, for procedural oxygenation and for weaning purposes both in the ICUs and the operating rooms. Apneic oxygenation can be used for procedural oxygenation and ventilation in short laryngeal procedures like dilatation of subglottic stenosis. Provided if the airway is unobstructed and full denitrogenation accomplished, oxygen saturation can be maintained for 65 mins [6].

Advantages

HFNO provides humidified oxygen with an immobile surgical field devoid of anesthetic devices. It provides improved surgical conditions with better field of view and better accessibility compared to standard anesthetic techniques. The rate of carbondioxide rise undergoing HFNC oxygenation is significantly less than classic apneic oxygenation. HFNO avoids potential complications associated with jet ventilation (barotrauma, pneumomediastinum, surgical emphysema and hypoxia). HFNO is considered a tubeless anesthesia, which can be protective from airway fire.

Results and Discussion

The limiting factor for using HFNO may not be oxygenation but carbondioxide retention and subsequent acidosis [7]. HFNO may fail to prolong apnea time in morbidly obese and in situations when total airway obstruction occurs. A secondary plan for ventilation should always be available. Anesthetic method using HFNO in subglottic stenosis; at our institution, we pre-oxygenate once the patient is in the operating room at 40 degress of head up inclination with 40 litres/min of HFNC. Intravenous induction of anesthesia then commence after the application of standard ASA monitors with bolus of 2 mg/kg to 3 mg/kg protocol, 1 mcg/kg to 2 mcg/kg fentanyl and 1 mg/kg to 1.5 mg/kg of succinylcholine or 0.5 mg/kg rocuronium (depends on procedure duration and co morbid conditions). After chemical paralysis, HFNC increased to 70 litre/min and is maintained through out the procedure. Operating table is turned towards otolaryngologist 90 degrees away from the anesthesia work station. Patency of the airway is ensured till direct suspension laryngoscopy performed by the otolaryngologist. During the procedure, microlaryngoscopy tube is provided to the otolaryngologist who intubate the patient under direct vision upon desaturation. Procedure is reinstated and patient extubated once adequate oxygenation and normocarbia achieved with positive pressure ventilation. This cycle is repeated many times as needed till the end of the procedure. We prefer to intubate the patient at the end of procedure with a MLT tube till the patient is fully awake as patient is at risk for perioperative complications (laryngospasm, airway edema, aspiration with secretions related to airway procedure). All patients received 0.1 mg/kg of dexamethasone and is reversed with suggamadex (in case of rocuronium), we extubate our patient fully awake and titrate the HFNC to facemask before shifting the patient to post-operative care unit. Current evidence and clinical applications. Shared airway surgery is a challenge for both surgeons and anesthesiologists. Recently HFNO has gained popularity in providing gas exchange with the advantage of better visualization of operative field to the surgeons.

Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) administered by HFNO associated with jaw thrust may extend the safe apneic window for patients with known or anticipated difficult airway. Use HFNO in 25 patients for preoxygenation undergoing general anesthesia for hypopharyngeal or laryngotracheal surgery. Patients were preoxygenated at 40 degrees of head up with 70 litre/min for 10 minutes, then decrease to 20 degrees after induction for laryngoscopy. HFNO was maintained till definitive airway was established. Apnea time was calculated between the administration of neuromuscular blockade till either jet ventilation, positive pressure ventilation or spontaneous ventilation. Average apnea time was 17 minutes, no patient experienced desaturation below 90% and none of the patient developed complications suggestive of carbondioxide toxicity [6]. Though apneic oxygenation provides little clearance of carbondioxide. THRIVE was an observational and cross sectional study and the effect on carbondioxide retension was not studied, which is the limiting factor in using HFNO. More recently, studied the effect of HFNO on carbondioxide accumulation and subsequent drop in PH in 31 adult patient undergoing general anesthesia for a laryngeal procedures. All patients were preoxygenated with either 40 litres/min of HFNC for 3 mins or to take four full vital capacity breaths for 2 mins. Arterial line was inserted in all patients pre induction and arterial gas samples taken every 5 mins.

Airway was kept patent with jaw thrust by the anesthesiologist till surgeons rigid tubular laryngoscope placed in full suspension to ensure a patent airway at all times. HFNC was increased to 70 litres/min with the onset of apnea and maintained through out the procedure. HFNC maintained oxygenation up to 30 min and none of the patients desaturated below 91% with an arterial pH of 7.13 or above.

The increase of $PaCO_2$ was approximately 0.24 kPa/min in contrast to less marked increase of 0.12 KPa/min when capnography was used [8]. It is speculated that with this mass flow of oxygen in a patent airway, some amount of carbondioxide is flushed out (dead space) resulting in lower CO_2 accumulation. Only patients with ASA less than 3 and BMI less than 30 were included in the study and randomization between hyperventilation and non hyperventilation group were not double blind. Spontaneous Respiration using Intravenous anesthesia and Hi flow nasal oxygen (STRIVE) a retrospective observational study in 30 adult patients undergoing microlaryngoscopic surgery.

Patients were preoxygenated with HFNC at a rate of 30 litres/min for 1 min followed by 50 litres/min for two minutes in a 10 degree to 20 degree reverse trendelenburg position. Patients were induced and maintained with TCI propofol and HFNO was increased to 70 litres/min from loss of consciousness till the end of procedure. No patient experienced desaturation less than 90%while the FiO_2 was 1, three patients experienced desaturation less than 90% when FiO_2 was reduced to 0.3 for laser but responded when FiO_2 was increased to 1. The mean rate of carbondioxide increase was 0.03 kpa Min with endtidal and 0.035 kpa.min with arterial blood gas. Upper airway instrumentation for airway patency were less common in STRIVE Hi in contrast to STRIVE alone [9]. To successfully utilized HFNO for apneic oxygenation in a case series of 17 patients undergoing subglottic stenosis [10].

It is speculated HFNO can provide added benefit in laser airway surgeries since it is tubeless. There has been one case report of airway fire with monopolar diathermy with THRIVE during hard palate biopsy and FiO_2 was reported 1 at the time of incident [11].

Conclusion

There is no standard of anesthetic practice for subglottic stenosis surgeries. HFNO provide favourable surgical conditions compared with a conventional anesthetic technique using tracheal tube, jet ventilation or apnea combined with mask ventilation for laryngeal surgeries. It decreases the risk of airway trauma by decreasing the frequency of intubations during the procedure. It can beutilize both with spontaneous and apneic induced procedures, though carbondioxide accumulation were more pronounced with apneic patients. As surgeons work in the airway, patients can be ventilated to treat hypoxemia and hypercarbia with an appropriate size endotracheal tube whenever necessary. This technique may decrease operative time as it provides better operative visibility for the surgeons and a static field as compared to conventional anesthetic technique. Current evidence is about ASA I-II patients with BMI below 30, therefore we strongly suggest to consider HFNO as an alternate anesthetic technique in this patient population. Furthermore, it is important to evaluate HFNO with more pronounced disease as well as in obese patients.

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