Scientific Research Publishing

Open Journal of Anesthesiology, 2023, 13, 234-240
https://www.scirp.org/journal/ojanes
ISSN Online: 2164-5558
ISSN Print: 2164-5531

Optimizing Surgical Conditions with the Use of a Modified Spontaneous Respiration, Intravenous Anesthesia and High-Flow Nasal Oxygen for Pediatric Laser Laryngeal Surgery

Dennis E. Feierman[1*], Daniel Escobar[1], Kim T. Lam[1], Mark Kronenfeld[1], Jacob Sutton[2], Evan P. Salant[1]

[1]Maimonides Medical Center, Department of Anesthesiology, Brooklyn, NY, USA
[2]Northwell Staten Island University Hospital, New York, USA
Email: *dfeierman@maimonidesmed.org, daniel4up@gmail.com, kimtuyen@gmail.com, MKronenfeld@maimonidesmed.org, ESalant@maimonidesmed.org, jsutton000@citymail.cuny.edu

How to cite this paper: Feierman, D.E., Escobar, D., Lam, K.T., Kronenfeld, M., Sutton, J. and Salant, E.P. (2023) Optimizing Surgical Conditions with the Use of a Modified Spontaneous Respiration, Intravenous Anesthesia and High-Flow Nasal Oxygen for Pediatric Laser Laryngeal Surgery. *Open Journal of Anesthesiology*, **13**, 234-240.
https://doi.org/10.4236/ojanes.2023.1311022

Received: October 6, 2023
Accepted: November 10, 2023
Published: November 13, 2023

Abstract

The use of SponTaneous Respiration using IntraVEnous anesthesia and High-flow nasal oxygen (STRIVE-Hi) in laryngeal surgery has become more widely reported. This method eliminates the endotracheal tube as a fuel for a potential fire. However, little has been published on its use in the pediatric population. Our case report describes its use in a 2-year-old undergoing micro-direct laryngoscopy with CO_2 assisted supraglottoplasty and rigid bronchoscopy for airway obstruction from congenital laryngomalacia. The STRIVE-Hi technique was modified for the pediatric patient by using a lower flow through the nasal cannula (4 L). No major changes in SpO_2 were detected during the 30-minute procedure. With back up airway safety equipment in place, STRIVE is proving to be a safe technique with major advantages when used in this unique scenario.

Keywords

STRIVE, Pediatric, Direct Laryngoscopy, Laryngomalacia

1. Introduction

Airway fires in the OR are rare but potentially devastating events. OR fires are estimated to occur 20 - 650 times annually [1] [2] [3]. Out of these cases, approximately 20 - 30 are disabling or disfiguring and can even be fatal [3]. Airway fires occur when a fire occurs in the patient's airway, compared to a surgical fire which occurs on the patient. Patients are at higher risk when undergoing a surgical procedure in an oxidant enriched environment. An oxidant enriched environment is produced when oxygen concentrations are elevated and, or nitrous oxide is used. Accidental contact with the laser beam used in the surgical process to the endotracheal tube, surgical swabs, or surgical drapes in the presence of an oxidant enriched environment can be enough to start a devastating fire. Endotracheal tube ignition has been a major cause of fires since the early stages of laser surgery. It had been reported that in around 1.5% of patients undergoing laryngeal laser surgery endotracheal tube ignition was the cause of a fire within the OR [3]. Endotracheal tubes can be made out of material which is easily damaged and readily ignited. The least safe tube to use is a poly-vinyl tube due to its effortless ability to be penetrated and then rapidly ignite within low oxygen levels [3]. Using a standard tube wrapped in foil tape may be a safer option when it comes to endotracheal ignition, however, there are still risks such as mucosal damage and detachment of the foil tape, thus maintaining its risks of harm or inflammation [1] [3] [4]. A review of energy-based surgical device related injuries reported to the FDA found that an estimated 67% - 85% of fires occurred when these were used in a head, neck, or upper chest operation. Oxygen in these scenarios has been reported to be four times more likely to be an oxidizer compared to other fuel options, thus leading to a larger number of surgical fires. [1] [2] As it is commonly advised, careful management of elements in the "fire triad" is essential in fire prevention. The "fire triad" is composed of an oxidizer (e.g. oxygen, nitrous oxide), a fuel (e.g. drapes, endotracheal tube) and a source of ignition (e.g. electrosurgery, burrs, drills, laser, fiberoptic scopes). Currently we attempt to mitigate fire risk by minimizing oxygen/nitrous oxide concentration, using reinforced ETTs and removing other potential fuels. However, these methods are not always feasible in the context of intraoral or laryngeal surgery.

Over recent years, a new airway management technique has been employed. This has been referred to as SponTaneous Respiration using IntraVEnous anesthesia and High-flow nasal oxygen (STRIVE-Hi) [5] or as Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) in the literature. STRIVE_Hi differs from THRIVE in that the patient is spontaneously breathing, whereas THRIVE uses apneic oxygenation. Unlike STRIVE-Hi/THRIVE, other oxygenation and ventilation options have clear disadvantages. When using an endotracheal tube (ETT), this tends to block the posterior glottis, and by using jet ventilation (JV), this can cause movement in the structures of the larynx causing complications like laryngeal trauma. Both STRIVE-Hi and THRIVE eliminate these disadvantages by creating a surgical field with a clear line of vision through tubeless oxygenation [5] [6] [7]. Other methods included high flow nasal cannula (HFNC) with apneic oxygenation. In adults STRIVE-Hi includes the use of spontaneous respiration with high flow (70 L/min) humidified nasal oxygen in concert with intravenous anesthesia. Originally used for emergency department respiratory failure, this method of oxygenation and its adoption to anesthesiology has transformed the process of airway management. [7] [8] There have been many reported cases in managing patients undergoing laryngeal procedures. Most of these cases have found using THRIVE within various otolaryngological procedures have been successful in maintaining enough oxygen throughout the whole procedure, while also extending the apneic window when used for pre-oxygen [8] [9]. THRIVE has also created a significantly improved field of view within laryngeal procedures due to the ventilation being via a nasal cannula [5] [6] [7] [8]. Experts have shown support in regard to the use of THRIVE/HFNC especially in regard to airway fires. [7] This new method, while allowing for adequate oxygenation and optimal surgical exposure, greatly reduces fire risks by eliminating the use of endotracheal tubes, the most common fuel source in laryngeal surgery, ultimately eliminating the fire triad. If all safety measures have been considered properly, this can limit the risk of airway fires significantly. While most case series have included adult patients, fewer have reported its use in the pediatric population. Our case report highlights this technique with a modification of using a lower flow of nasal oxygen (4 L NC) which would be adequate in a 2-year-old.

2. Case Presentation

Patient's history: A 2-year-old full term 14 kg male, presented with persistent airway obstruction from redundant tissue requiring rigid laryngoscopy, bronchoscopy, and supraglottoplasty. Patient was born via uncomplicated vaginal delivery and is up to date on immunizations. Past surgical history included a tonsillectomy and adenoidectomy. Significant past medical history includes obstructive sleep apnea (OSA) (diagnosed at 14 months old with, AHI = 12.2), recurrent upper respiratory infections and the inability to run secondary to upper airway obstruction with significant stridor.

A video assisted fiberoptic done at 4 weeks post-delivery revealed redundant arytenoid mucosa prolapsing into the airway along with redundant supraglottic and post-cricoid mucosa resulting in airway narrowing. He was initially medically managed with Ranitidine and Deep-Sea Nasal 0.65% nasal spray for approximately 3 months along with monthly follow up visits. The patient's parents noted that his symptoms initially improved: breathing well, and less spitting up after feeds. However, he continued to have stridor during the day time. Polysomnography study done when the patient was 14 months old showed SaO_2 89%, end tidal CO_2 42 mmHg, AI = 1.4, AHI = 12.2.

He underwent a tonsillectomy and adenoidectomy at 20 months old for OSA and recurrent upper respiratory infections. Additionally, there was concern for speech delay at that time. This patient continued to have progressive worsening of this airway obstruction requiring intervention.

Preoperative: A multidisciplinary team devised a plan that included a micro-direct laryngoscopy with supraglottoplasty and rigid bronchoscopy with the use of STRIVE-Hi. The use of STRIVE-HI was chosen over THRIVE, was that the otolaryngologist could actually see the movement of the structures of the airway. Additionally, if the patient went apneic could easily increase the nasal canula flow and convert to the use of apneic oxygenation (THRIVE)

Typically, this procedure is carried out a rigid suspended laryngoscopy, rigid bronchoscopy and intermittent ventilations with lower than 100% FiO_2. This usually increases the procedure time since the procedure is paused when the patient needs to be intermittently ventilated for desaturations. There is also a significant concern for airway fires since the triad of laser (source of ignition), and oxygen (oxidizer) must be used and a fuel (e.g., re-enforced ET-tube, or a gauze sponge) can be present. To minimize these risks, a STRIVE-Hi technique was used. The potential complications of this method were laryngospasm and the inability to maintain adequate oxygenation [5]; however, leaving out the fuel, high concentrations of oxygen can be used without causing a fire [3].

Intraoperative: Upon arrival to the operating room, standard ASA monitors were applied, the patient was induced with 8% Sevoflurane and a 22-gauge intravenous line (IV) was placed. A propofol infusion was started at initial rate of 500 mcg/kg/min and he was placed on nasal cannula at 4 L/min (equivalent to 20 L/min in a 75 kg adult). Glycopyrrolate (0.008 mcg/kg) and Tylenol (15 mg/kg) were given immediately after the IV was place. We avoided the use narcotic and benzodiazepines (No premedication). We monitored the ETCO2 via the nasal cannula as we titrated the anesthetic to a level needed for these procedures. When the $ETCO_2$ decreased from baseline, we would decrease the infusion by 50 mcg/kg/min down to 400 mcg/kg/min. When the pattern and the $ETCO_2$ increased from baseline, we would increase the infusion by 50 mcg/kg/min until 800 mcg/kg/min, but we have used up to 1000 mcg/kg/min. If the patient responds, we increase the infusion. The Otolaryngologist does a "test" laryngoscopy and anesthetized the vocal cords and surrounding tissue with topical 2% lidocaine. In this case, we had excellent conditions with 800 mcg/kg/min. Without the presence of the endotracheal tube, the surgical team had a full unobstructed view of the surgical site (**Figure 1**). And, since the patient was spontaneously breathing they were able to observe the airway dynamics. If the patient became apneic, we

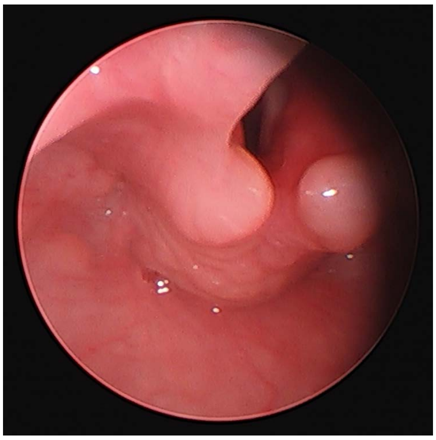

Figure 1. Direct rigid laryngoscopy was performed. Then redundant tissue around the arytenoids is easily seen.

would increase the nasal cannula to 12 L/min and use a THRIVE technique. At this point, the surgical team used suspended direct rigid laryngoscopy and a CO_2 laser to excise the excess arytenoid tissue in multiple steps: the resection of the excesses tissue was guided by the residual degree of prolapse after each excision (**Figure 2**).

We were unable to capture $ETCO_2$ capnography due to the patient's mouth being held open for the rigid bronchoscope and surgical manipulations (**Figure 3**). Placing a small CO_2 sampling port alongside the laryngoscope or inside the patient airway is not advisable since it can act as a fuel. The anesthesia team was able to evaluate and confirm that the patient was maintaining spontaneous respiration since this could be visualized on the screen of the monitor displaying view from microscope. The patient was hemodynamically stable and SpO_2 remained at 99% - 100% (using 4 L of 100% O_2 via a nasal canula) for the entire duration of the case.

Postoperative: The patient was transferred to PICU for close observation. He had an uneventful PACU course, and discharged home on post-op day #1.

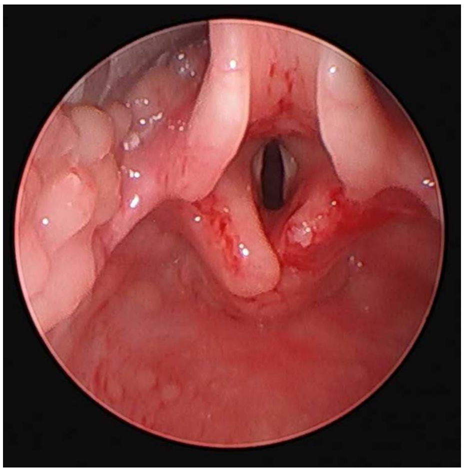

Figure 2. Picture after partial laser supraglottoplasty.

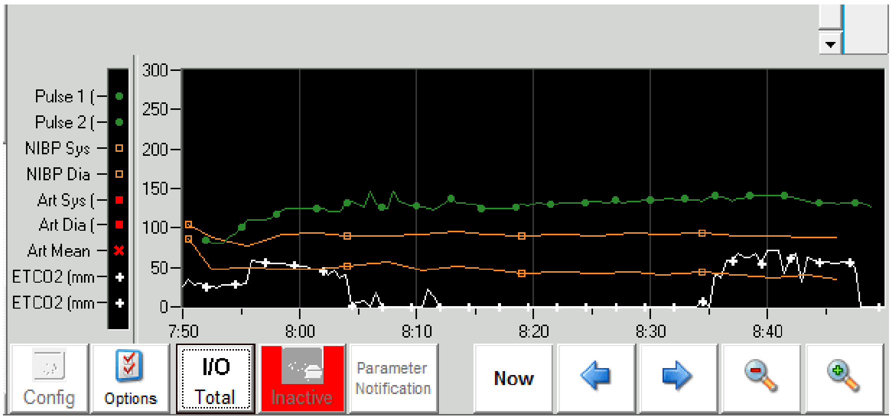

Figure 3. Vital signs tracing: Heart rate in green, Blood pressure in orange, and $ETCO_2$ in white. During the procedure we were unable to monitor the $ETCO_2$. At the end of the procedure $ETCO_2$ tracing returned.

Post-operative follow up two weeks later noted patient's breathing has improved and was no longer stridulous, additionally, there was no dysphagia or dyspnea.

3. Discussion

STRIVE Hi had beneficial effects with oxygenation, ventilation, and airway patency in our patient undergoing micro-laryngeal surgery [5]. During the administration of anesthesia, there were no desaturations, episodes of apnea, or complete airway obstruction. Ventilation was preserved at deep levels of anesthesia. Fire risk was significantly lowered by removing the endotracheal tube and any potential fuels from the airway.

Different protocols have been described. A retrospective analysis by Booth *et al.* reviewed the use of STRIVE Hi in 30 adult patients for micro-laryngeal surgery [5]. High flow nasal oxygen had been described, but not with spontaneous breathing under general anesthesia. Similar benefits were found but it was also advocated that use of high flow increases margin of safety and assists in preventing airway collapse caused by propofol. That became the protocol of choice at his institution for tubeless laryngeal surgery. In contrast to Booth *et al.* high flow technique, we successfully used lower flow 4 LNC.

Galloway *et al.* similarly employed this technique with nasal cannula for maintenance ventilation in a group of 20 neonates and toddlers undergoing frenulectomies [10]. With a flow of 4 L/min and lowered FiO_2 (30%,) they did not experience any complications or desaturations. They argue a high riding epiglottis which sits behind the soft palate favors flow through the nasal cannula as compared to adults. Although limited to a single procedure, Galloway's study endorses use of this technique for micro-laryngeal surgery. Since we had did not place anything in the airway that could be used as a fuel for fire, we used 100% O_2 to minimize the potential for desaturation and furthermore, it would enable us to switch to apneic oxygenation (THRIVE), if the need occurred. As they point out, key factors to this technique are establishing the proper plane of anesthesia (with orderly spontaneous ventilation,) careful hemostasis, proper ASA monitoring and being prepared with other forms of managing the airway if needed.

This case, it is a good example of STRIVE method can be done safely and ought to be considered in pediatric micro-laryngeal surgery. The use of STRIVE-HI was chosen because the otolaryngologist could see the movement of the structures of the airway and tailor the operation to the patient's needs. With an endotracheal tube there would be an additional risk of airway fire as well as a partially obstructed view and further, the inability to see the structures move. Although THRIVE would eliminate the first two concerns, the third advantage of STRIVE-Hi would still be missing. With proper oversight of the airway from both anesthesia and ENT, fire risk and surgical exposure become more relevant to the anesthetic plan. Having back up strategies to manage the airway is still important.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Jones, T.S., Black, I.H., *et al.* (2019) Operating Room Fires. *Anesthesiology*, **130**, 492-501. https://doi.org/10.1097/ALN.0000000000002598

[2] Overbey, D.M., Townsen, M., *et al.*, (2015) Surgical Energy-Based Device Injuries and Fatalities Reported to the Food and Drug Administration. *Journal of the American College of Surgeons,* **221**, 197-205e1. https://doi.org/10.1016/j.jamcollsurg.2015.03.031

[3] Yardley, I.E. and Donaldson, L.J. (2010) Surgical Fires, a Clear and Present Danger. *The Surgeon*, **8**, 87-92. https://doi.org/10.1016/j.surge.2010.01.005

[4] Apfelbaum, J.L., Caplan, R.A., *et al.*, (2013) Practice Advisory for the Prevention and Management of Operating Room Fires: An Updated Report by the American Society of Anesthesiologists Task Force on Operating Room Fires. *Anesthesiology*, **118**, 271-290. https://doi.org/10.1097/ALN.0b013e31827773d2

[5] Booth, A.W.G., Vidhani, K., Lee, P.K. and Thomsett, C.-M. (2017) SponTaneous Respiration Using IntraVEnous Anaesthesia and Hi-Flow Nasal Oxygen (STRIVE Hi) Maintains Oxygenation and Airway Patency during Management of the Obstructed Airway: An Observational Study. *British Journal of Anaesthesia*, **118**, 444-451. https://doi.org/10.1093/bja/aew468

[6] Benninger, M.S., *et al.* (2021) Utility of Transnasal Humidified Rapid Insufflation Ventilatory Exchange for Microlaryngeal Surgery. *Laryngoscope*, **131**, 587-591. https://doi.org/10.1002/lary.28776

[7] Flach, S., Elhoweris, A., Majumdar, S., Crawley, S. and Manickavasagam, J. (2019) Transoral Laser Microsurgery Using High-Flow Nasal Cannula Oxygenation: Our Experience of 21 Cases. *Clinical Otolaryngology*, **44**, 871-874. https://doi.org/10.1111/coa.13398

[8] Patel, A. and Nouraei, S.A.R. (2015) Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): A Physiological Method of Increasing Apnoea Time in Patients with Difficult Airways. *Anaesthesia*, **70**, 323-329. https://doi.org/10.1111/anae.12923

[9] Lau, J., Loizou, P., Riffat, F., Stokan, M. and Palme, C.E. (2019) The Use of THRIVE in Otolaryngology: Our Experiences in Two Australian Tertiary Facilities. *Australian Journal of Otolaryngology*, **2**, 22. https://doi.org/10.21037/ajo.2019.07.02

[10] Galloway, K., Fernandez-Salvador, C., Heffner, K. and Camacho, M. (2020) Nasal Cannula Technique for Ventilating during the Administration of General Anesthesia in Neonates and Pediatric Patients. *Cranio*, **38**, 131-134. https://doi.org/10.1080/08869634.2018.1507490