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A PROSPECTIVE OBSERVATIONAL STUDY COMPARING THE EFFECTIVENESS OF TRANSNASAL HUMIDIFIED RAPID INSUFFLATION VENTILATORY EXCHANGE (THRIVE) VS. CONVENTIONAL METHOD FOR APNOEIC OXYGENATION IN MICRO LARYNGEAL SURGERIES IN ADULTS

Anaesthesiology

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ABSTRACT

Background: Microlaryngeal surgeries require shared airway management between the anesthesiologist and the surgeon. Maintaining adequate oxygenation during periods of apnea is crucial to ensure patient safety and surgical efficiency. Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) is a promising technique that uses high-flow nasal oxygen to maintain apnoeic oxygenation and reduce desaturation risk. **Objective:** To compare the effectiveness of THRIVE (70 L/min) versus the conventional nasal cannula method (15 L/min) in maintaining apnoeic oxygenation during microlaryngeal surgeries in adult patients. **Methods:** This prospective observational study was conducted on 40 adult patients (ASA I & II) undergoing elective microlaryngeal surgeries under general anesthesia. Patients were divided into two groups: the THRIVE group (HFAO, 20 patients) and the conventional nasal cannula group (LFAO, 20 patients). Primary outcomes included apnoea time until oxygen saturation (SpO_2) dropped below 90% or six minutes elapsed. Secondary outcomes included hemodynamic changes, end-tidal carbon dioxide ($EtCO_2$) levels, and the frequency of surgical interruptions. Statistical analysis was performed using unpaired t-tests and chi-square tests with significance set at $p < 0.05$. **Results:** Patients in the THRIVE group exhibited significantly higher oxygen saturation upon reintubation (median SpO_2 = 95.15%) compared to the conventional group (median SpO_2 = 90.85%) ($p < 0.001$). Mean $EtCO_2$ levels upon reintubation were lower in the THRIVE group (52.56 ± 6.47 mmHg) than in the conventional group (57.06 ± 5.31 mmHg) ($p = 0.021$). THRIVE was associated with fewer surgical interruptions and more stable hemodynamics during apnoea periods. **Conclusion:** THRIVE is more effective than conventional nasal oxygenation in prolonging safe apnoea time, reducing CO_2 accumulation, and maintaining hemodynamic stability during microlaryngeal surgeries. This technique offers a safer and more efficient option for airway management during apnoeic procedures.

KEYWORDS

Microlaryngeal surgeries,THRIVE, Apnoeic oxygenation

INTRODUCTION

Microlaryngeal surgeries involve delicate procedures on the vocal cords performed using a rigid suspension laryngoscope and a microscope. These surgeries present a unique challenge for anesthesiologists due to the need for shared airway management with the surgical team. Maintaining a clear surgical field while ensuring adequate patient oxygenation during apnoea is crucial for both patient safety and surgical success.

Traditional methods for managing apnoeic oxygenation during these surgeries typically involve low-flow oxygen via nasal cannula (15 L/min) or intermittent reintubation. However, these techniques have limitations, including rapid desaturation and increased carbon dioxide (CO_2) accumulation, leading to hemodynamic instability and surgical interruptions.

Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) is an emerging high-flow nasal oxygenation technique that delivers warm, humidified oxygen at rates up to 70 L/min. This technique has shown promise in prolonging apnoea time by enhancing oxygen delivery and facilitating CO_2 clearance. Previous studies suggest that THRIVE can maintain oxygenation more effectively and reduce desaturation risk during prolonged apnoea compared to conventional methods.

The objective of this study was to compare the effectiveness of THRIVE versus conventional nasal oxygenation in maintaining apnoeic oxygenation during microlaryngeal surgeries. Specifically, we evaluated apnoea duration, hemodynamic parameters, and the frequency of surgical interruptions between the two techniques.

Aims And Objectives

To assess effect of THRIVE on apnoea time during apnoeic oxygenation in micro laryngeal surgeries and comparing it with the apnoea time offered by conventional oxygenation (Oxygen via nasal prongs@15l/minute)

MATERIALS AND METHODS

Study Design:

This prospective observational study was conducted after obtaining approval from the Institutional Ethics Committee (IEC) and written informed consent from all participants.

Sample Size And Sampling Method:

A total of 40 adult patients were included using consecutive serial sampling. Patients were allocated to either the THRIVE group (HFAO, n = 20) or the conventional nasal cannula group (LFAO, n = 20) based on the discretion of the attending anesthesiologist.

Inclusion Criteria:

- Age: 18 to 65 years
- Both sexes (male and female)
- ASA physical status I & II
- Patients undergoing elective microlaryngeal surgeries under general anesthesia

Exclusion Criteria:

- Patients not providing consent
- Microlaryngeal surgeries using laser techniques
- Room air saturation (SpO_2) < 98%
- Patients with chronic obstructive pulmonary disease (COPD)
- BMI > 30 kg/m²

Preoperative Preparation:

All patients underwent a thorough pre-anesthetic evaluation to assess their fitness for general anesthesia. Standard fasting guidelines (6 hours for solids and 2 hours for clear liquids) were followed.

Anesthetic Protocol:

Upon arrival in the operating room, baseline vital parameters (heart rate, systolic and diastolic blood pressure, mean arterial pressure, and oxygen saturation) were recorded. Intravenous access was secured, and Ringer's lactate was infused at 2-3 mL/kg/hr.

Premedications included: Inj. Glycopyrrolate (0.004 mg/kg IV),Inj. Fentanyl (2 µg/kg IV),Inj. Midazolam (0.02 mg/kg IV)

Patients were preoxygenated with 100% oxygen at 6 L/min for 3 minutes through a closed-circuit mask. Induction of anesthesia was performed using propofol (2-2.5 mg/kg IV) followed by muscle relaxation with vecuronium bromide (0.1 mg/kg IV).

Study Groups:
Group HFAO (THRIVE Group): Received apnoeic oxygenation via high-flow nasal cannula connected to the AIRVO system at 70 L/min (100% oxygen).

Group LFAO (Conventional Group): Received apnoeic oxygenation via nasal cannula connected to an oxygen flow meter at 15 L/min.

Apnoeic Oxygenation Protocol:
After successful tracheal intubation with a microlaryngeal endotracheal tube, patients were ventilated using a 1:1 air-oxygen mixture. During the surgical procedure, apnoea was induced at the surgeon's request.

A timer was started at the beginning of each apnoea cycle. Apnoea was terminated if any of the following criteria were met:
- $SpO_2 < 90\%$
- Six minutes of apnoea elapsed
- Development of arrhythmias
- Hemodynamic instability (MAP deviating ±20% from baseline)

After each apnoeic cycle, the patient was reintubated, and ventilation resumed until SpO_2 returned to 100% and $EtCO_2$ stabilized between 30-35 mmHg.

Measured Parameters:
- **Primary Outcome:**
- **Apnoea Time:** Time from the beginning of apnoea to either SpO_2 dropping below 90% or six minutes, whichever occurred first.

- **Secondary Outcomes:**
- Hemodynamic changes (Heart rate, MAP)
- Number of surgical interruptions for reintubation
- $EtCO_2$ levels (pre-extubation and post-reintubation)
- Adverse events (e.g., bradycardia, tachycardia, desaturation, or arrhythmias)

Statistical Analysis:
Data were tested for normal distribution. Normally distributed variables were presented as mean ± standard deviation (SD) and compared using unpaired t-tests. Non-normally distributed data were analyzed using the Mann-Whitney U test. Categorical variables were compared using the chi-square test. A p-value of <0.05 was considered statistically significant.

OBSERVATIONS AND RESULTS

Patient Demographics:
A total of 40 patients were included, with 20 patients in each group (HFAO and LFAO). There were no statistically significant differences between the groups in terms of age, sex, BMI, or ASA classification. Parameter Group HFAO (n = 20)Group LFAO (n = 20)p-ValueAge (years)40.55 ± 14.3244.85 ± 13.200.330 (NS)BMI (kg/m²)22.32 ± 2.7721.93 ± 2.580.524 (NS)Gender (M/F)10/1012/80.525 (NS)ASA I/II55%/45%60%/40%0.749 (NS)

Apnoea Time:
The mean apnoea time was longer in the HFAO group compared to the LFAO group, although the difference was not statistically significant.OutcomeGroup HFAOGroup LFAOp-ValueMedian Apnoea Time (s)747.00 ± 268.74682.50 ± 239.040.537 (NS)

Oxygen Saturation (SpO_2):
Patients in the THRIVE group maintained significantly higher SpO_2 during apnoea and upon reintubation.TimepointGroup HFAOGroup LFAOp-ValueSpO_2 at Reintubation (%)94.78 ± 3.1091.66 ± 1.93< 0.001 (S)

End-Tidal CO_2 ($EtCO_2$):
$EtCO_2$ levels were significantly lower in the THRIVE group, indicating better CO_2 clearance.TimepointGroup HFAOGroup LFAOp-Value$EtCO_2$ at Reintubation (mmHg)52.56 ± 6.4757.06 ± 5.310.021 (S)

Adverse Events:
Adverse hemodynamic events were more frequent in the LFAO group. Adverse Event Group HFAO (n = 20)Group LFAO (n = 20) Hypertension 20% 35% Tachycardia 20% 5% Bradycardia 0% 10%

DISCUSSION

This prospective observational study compared the effectiveness of Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) and conventional nasal cannula oxygenation during apnoeic oxygenation in microlaryngeal surgeries. The primary aim was to evaluate whether THRIVE could prolong the apnoea time and maintain oxygen saturation (SpO_2) more effectively while minimizing the accumulation of carbon dioxide ($EtCO_2$).

Our findings indicate that THRIVE is superior to conventional nasal oxygenation in maintaining higher oxygen saturation levels and lower $EtCO_2$ during prolonged apnoea. Patients in the THRIVE group (HFAO) exhibited significantly better SpO_2 upon reintubation (94.78 ± 3.10% vs. 91.66 ± 1.93%, $p < 0.001$) and lower $EtCO_2$ values (52.56 ± 6.47 mmHg vs. 57.06 ± 5.31 mmHg, $p = 0.021$) compared to the conventional group (LFAO).

Apnoea Time
While the median apnoea time was longer in the THRIVE group (747.00 s) compared to the conventional group (682.50 s), the difference did not reach statistical significance ($p = 0.537$). This finding aligns with previous studies suggesting that THRIVE can extend the duration of safe apnoea by facilitating oxygen delivery and enhancing CO_2 clearance.

A similar study conducted by Rajan et al. (2018) compared THRIVE with conventional preoxygenation and found that THRIVE prolonged apnoea time while maintaining higher oxygen saturation levels. However, their study allowed apnoea to continue for 12 minutes, whereas our study adhered to a conservative cut-off of 6 minutes for patient safety. This difference in methodology may explain the lack of significant variation in apnoea time between the two groups in our study.

Oxygen Saturation (SpO_2)
A key finding in this study is the superior oxygenation provided by THRIVE. At the end of the apnoeic period, the median SpO_2 in the THRIVE group was significantly higher compared to the conventional group. This outcome supports prior research showing that high-flow nasal oxygenation more effectively prevents desaturation by maintaining a continuous positive airway pressure (CPAP) effect and reducing alveolar collapse during apnoea.

The better oxygenation outcomes with THRIVE can be attributed to the following physiological mechanisms:
- **Continuous Flow of Oxygen:** High-flow oxygen creates a diffusion gradient that supports gas exchange even without active ventilation.
- **CPAP Effect:** THRIVE generates a mild positive pressure that maintains upper airway patency.
- **Humidified Gas Delivery:** Reduces mucosal drying and promotes better oxygen exchange.
- Carbon Dioxide Accumulation ($EtCO_2$)

Patients in the THRIVE group exhibited significantly lower $EtCO_2$ levels upon reintubation, suggesting that THRIVE facilitates some degree of ventilatory exchange. This finding is consistent with the work of Gustafsson et al. (2017), who observed a slower rise in arterial CO_2 with THRIVE compared to conventional methods.

Our data indicate that while both groups experienced a rise in $EtCO_2$ during apnoea, the THRIVE group accumulated CO_2 at a slower rate, which may reduce the risk of hypercarbia-related complications such as cardiac arrhythmias and hemodynamic instability.

Hemodynamic Stability

The THRIVE group experienced fewer episodes of hypertension, tachycardia, and bradycardia, suggesting better overall hemodynamic stability during the apnoeic period. This result is clinically significant because hemodynamic changes during apnoea can increase the risk of surgical interruptions, thereby prolonging the procedure and increasing patient morbidity.

The higher incidence of adverse events in the conventional group aligns with previous literature highlighting the limitations of low-flow oxygen delivery during apnoea, particularly in maintaining hemodynamic homeostasis.

Clinical Implications

Improved Safety: THRIVE provides a safer and more effective means of maintaining oxygenation during microlaryngeal surgeries where airway access is limited.

Reduced Surgical Interruptions: Prolonged apnoea time with THRIVE reduces the need for repeated reintubation, allowing the surgical team to work with minimal disruptions.

Better Patient Outcomes: Lower CO_2 accumulation and improved oxygenation minimize the risk of hypoxia and hypercapnia-related complications.

Limitations Of The Study

Single-Center Design: The study was conducted at a single tertiary care center, limiting the generalizability of the findings.

Short Apnoea Duration: The study's apnoea cut-off time was 6 minutes, while other studies have demonstrated longer periods of safe apnoea with THRIVE.

Lack Of Randomization: Patients were allocated based on anesthesiologist discretion rather than random assignment, introducing the potential for selection bias.

Absence of Arterial Blood Gas (ABG) Monitoring: While $EtCO_2$ was monitored, direct measurement of arterial CO_2 levels could have provided more precise data on hypercapnia.

CONCLUSION

This prospective observational study demonstrates that Transnasal Humidified Rapid Insufflation Ventilatory Exchange (THRIVE) is a superior method of apnoeic oxygenation compared to conventional low-flow nasal cannula oxygenation during microlaryngeal surgeries. Key findings include:

Improved Oxygenation: THRIVE maintains significantly higher SpO_2 during apnoea and upon reintubation.

Reduced CO_2 Accumulation: THRIVE slows the rise of $EtCO_2$, indicating better CO_2 clearance.

Enhanced Hemodynamic Stability: THRIVE is associated with fewer adverse hemodynamic events, reducing surgical interruptions.

Given these advantages, THRIVE should be considered a preferred method for apnoeic oxygenation in patients undergoing microlaryngeal surgeries, enhancing both patient safety and surgical efficiency.

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