

A prospective study on use of thrive (transnasal humidified rapid insufflation ventilatory exchange) versus conventional nasal oxygenation following extubation of adult cardiac surgical patients

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ABSTRACT

Background: Postoperative pulmonary complications in cardiac surgery increase mortality and morbidity. High flow nasal cannula oxygen therapy (HFNC) is one of the preventive measures to reduce the incidence of lung complications. HFNC can decrease dyspnea and improve physiologic parameters after extubation, including respiratory rate and heart rate, compared with conventional oxygen therapy. In this study, we evaluated the role of THRIVE (Transnasal Humidified Rapid Insufflation Ventilatory Exchange) after extubation.

Methodology: We prospectively randomized 60 adults aged between 18 and 65 years undergoing elective cardiac surgery to either High flow oxygen therapy using THRIVE (Group A) or conventional nasal cannula (group B). Arterial paO₂, paCO₂, pH at three points of time i.e., 1, 2, 4 hrs after extubation were evaluated using arterial blood gas analysis. Ventilation duration, the incidence of reintubation, sedation score, mortality, and other complications were also assessed.

Results: Thirty adults in each group had comparable patient characteristics. There was a statistically significant decline in paCO₂ in group A at 1, 2, 4 hrs post extubation ($P = 0.022, 0.02, <0.001$) with a significant increase in oxygenation ($P < 0.001$) when compared to group B. ICU stay duration was similar between two groups. No complications were noted in both groups.

Conclusion: THRIVE is safe to use following extubation in adult cardiac surgical patients.

Keywords: Conventional oxygen therapy, high flow oxygenation, THRIVE

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BACKGROUND

Extubation planning is important in cardiac surgery as impaired ventilation is common in postoperative period. It is necessary to decrease the risk of respiratory failure and reintubation which is associated with poor outcomes.^[1] Early mobilization, respiratory physiotherapy, mucolytic, and

incentive spirometry help in early respiratory rehabilitation. Other supportive measures of ventilation include oxygen therapy by nasal cannula, face mask, non-invasive ventilation and high flows^[2] THRIVE (Transnasal Humidified Rapid Insufflation Ventilatory Exchange) is a technique that

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provides rapid insufflated heated humidified gases through high flow nasal cannula for achieving apnoeic oxygenation and ventilation. HFNC provides oxygen at flows higher than patient's minute ventilation allowing delivered oxygen titration up to 100% with significant ventilation and gas exchange due to gaseous mixing and flushing of dead space secondary to high insufflation flows.^[3] It even creates PEEP up to 7 cm H₂O that prevents airway collapse and atelectasis.^[4] Humidified warm air limits mucosal injury, ciliary dysfunction and infection. Studies on apnoeic oxygenation have shown that techniques without CO₂ exchange have led to severe respiratory failure. With THRIVE, patients developed only mild hypercapnia than previous studies on apnoeic oxygenation causing arrhythmias and cardiac instability. THRIVE represents an easy way of achieving oxygenation and ventilation non-invasively.^[5]

METHODOLOGY

Study design and population

In this prospective study, 60 patients were recruited following informed consent. The study was approved by the institutional ethics committee. Inclusion criteria were aged between 18 and 65 years, elective cardiac surgery. Exclusion criteria were ASA greater than III, BMI greater than 30 kg/m², pre-existing respiratory pathology, neuromuscular disorders, previous history of GERD, pregnant and lactating women, history of epistaxis, nasal pathology, and emergency surgery. Sixty patients who fulfilled the study criteria were randomised into group A (THRIVE, *n* = 30) and group B (conventional nasal cannula oxygen, *n* = 30) based on a computer-generated random sequence of numbers and allocation concealment was done using sequentially numbered opaque sealed envelopes. Ethics committee approval was taken. date was 26-11-2018.

Objectives

To compare gas exchange (paO₂, paCo₂) between THRIVE and Conventional nasal oxygenation after 1, 2, 4 hrs of extubation in elective cardiac surgeries.

Secondary objectives- Incidence of reintubation, ventilation duration, the occurrence of any complications.

Cannula description and THRIVE

AIRVO TM 2 is a humidifier with an integrated flow generator that delivers warmed and humidified oxygen up to 60 l/min. In the THRIVE group, high flow warmed humidified oxygen was delivered through nasal cannula using AIRVO TM.^[6]

Anesthesia and recovery

A standardized protocol was followed for the induction and maintenance of anesthesia. Intraoperatively, continuous perioperative monitoring of central venous, systemic arterial pressures, SpO₂, ECG, nasopharyngeal temperature, and urine output were done. After shifting to recovery, patients were kept on a controlled mode of ventilation with all of the above monitoring in situ. After elective ventilation for 3 hrs, patients were assessed for spontaneous breathing trials. If patients have gained adequate muscle power, stable vitals, and satisfactory drain output, they were kept on spontaneous mode for 20–30 mins. If spontaneous CPAP trial was tolerated well, they were extubated and enrolled to either THRIVE (group A) or conventional nasal oxygenation (GROUP B).

INTERVENTIONS

Conventional nasal oxygen therapy was provided using a nasal cannula with flows of 4 liters/min. High flow oxygen therapy using THRIVE was delivered with 60 liters/min for 4 hrs and the study period ends at that point and then transferred to routine oxygen therapy.

Study parameters

paO₂, paCO₂, pH at three points of time i.e., 1, 2, 4 hrs after extubation were evaluated using arterial blood gas analysis. Duration of ventilation reintubation, sedation score and other complications were assessed.

Statistical analysis

It was carried out using SPSS software, version 16.0 (SPSS, Inc., USA). The Chi-square -test and independent-sample t-test were used to compare categorical and continuous variables, respectively. Data were presented as mean ± SD or proportion as appropriate. The “*p*” value less than 0.05 was considered to be significant.

RESULTS

Of 60 patients who were enrolled in the study were randomized into group A (THRIVE, *n* = 30) and group B (conventional nasal cannula, *n* = 30). Demographic data and type of surgery were comparable between two groups as shown in Table 1.

Parameters such as pao₂, pco₂, ph, Spo₂ at 1, 2, 4 hrs following extubation were shown in Table 2.

In Table 2, the arterial blood gas parameters such as pao₂ were higher in group A at 1, 2, 4 hrs post-extubation being statistically significant (*p* < 0.001). Similarly, paco₂'s were significantly less in group A (*p* = 0.022, 0.002, <0.001 at 1, 2, 4 hrs) in comparison to group B as shown in Figure 1.

The mean duration of ventilation was 4.75 ± 1.01 hr vs 4.88 ± 0.96 hr with the difference between the two groups being not significant ($p = 0.061$). The sedation score and ICU stay were comparable between the groups as shown in Table 3 ($P=0.707, 0.67$ respectively). No reintubation or mortality was noted in both groups. There were no complications in either of the groups.

DISCUSSION

Postoperative pulmonary complications in cardiac surgery increase mortality and morbidity. Development of pulmonary complications after cardiac surgery is multi-factorial; Atelectatic lung decreases FRC and increases right-left shunt after cardiac surgery, and

nonventilated lung regions constitute 20% of the total lung volume thereby causing postoperative hypoxemia. Others being alteration in the function of chest muscles and wall due to median sternotomy, systemic inflammatory response syndrome caused by establishing cardiopulmonary bypass, phrenic nerve damage by the administration of cold saline in the pericardial cavity during cardiac arrest and alveolar edema by left ventricular distension and elevated pressure in the pulmonary vasculature are considered the contributing factors for this lethal complication. They are associated with increased length of hospital stay and have a great influence on health care costs in cardiac surgical patients.

It is reported that the incidence of these complications ranges from 8% to 79%.^[7] Postoperative respiratory failure has perioperative mortality and morbidity in cardiac surgical patients. Prophylactic strategies such as postoperative physiotherapy, incentive spirometry non-invasive ventilation, high flows will reduce the incidence of pulmonary complications.^[8]

High flow oxygen therapy is one of the preventive measures to reduce the incidence of pulmonary complications. Compared with conventional oxygen therapy (COT), high flow therapy has several advantages: to produce PEEP, reduce anatomical dead space, provide a predictable and sustained FiO₂, to increase PaO₂/FiO₂, to improve mucociliary movements to move sputum, to reduce upper airway resistance and breathing work, to increase the coordination between chest and abdomen movements^[9]

THRIVE is a technique utilizing rapid insufflation of heated humidified gases delivered by high flow nasal cannula.^[10] In 2013, Patel and Nouraei introduced it using optiflow system resulting in an increase in apnoea time and a one-third rate of rising of co₂ during apnea. Thus, the concept of THRIVE was introduced.^[11] At 60 L/min co₂

Table 1: Demographic variables

	GROUP A	GROUP B	P
AGE (Mean±SD)	50.6±15.6	52.5±13.9	0.056
Sex		0.774	
Male	22 (51.2%)	21 (48.8%)	
Female	8 (47.1%)	9 (52.9%)	
BMI (Mean±SD)	21.34±5.6	22.9±3.5	0.530
Type of surgery		0.114	
CABG (off pump)	12 (38.7%)	19 (61.3%)	
MVR	7 (70%)	3 (30%)	
AVR	3 (37.5)	5 (62.5%)	
DVR	8 (72.7%)	3 (27.3%)	
Onpump surgeries	18	11	0.07
Offpump surgeries	12	19	

Table 2: paO₂, pCO₂,ph, SpO₂ at 1,2,4 hrs postextubation

	Group A mean±SD	Group B mean±SD	P
paO ₂			
paO ₂ 1	348±80.53	111.60±19.55	<0.001
paO ₂ 2	330.63±87.47	106.73±20.29	<0.001
paO ₂ 3	339.23±83.23	99.43±17.78	<0.001
paCO ₂			
pCO ₂ 1	35.50±3.02	37.47±3.44	0.022
pCO ₂ 2	35.07±2.57	37.70±3.68	0.002
pCO ₂ 3	33.80±2.61	37.27±3.06	<0.001
pH			
pH1	7.41±0.045	7.42±0.027	0.057
pH2	7.41±0.043	7.41±0.032	0.920
pH3	7.41±0.042	7.41±0.025	0.942
SpO ₂			
spO ₂ 1	100±0.0	99.70±0.794	0.043
spO ₂ 2	100±0.0	99.43±0.935	0.002
spO ₂ 3	100±0.0	99.13±0.973	<0.001

Table 3: Postoperative variables

	Group A mean±SD	Group B mean±SD	P
ICU stay	3.41±1.42	3.76±1.31	0.67
Ramsay sedation score	1.87±0.776	2.00±0.743	0.499
1 (No, %)	11 (57.9)	8 (42.1)	0.707
2 (No, %)	12 (46.2)	14 (53.8)	
3 (No, %)	7 (46.7)	8 (53.3)	
Ventilatory hours	4.75±1.01	4.88±0.96	0.061
Reintubation	nil	Nil	
Mortality	nil	Nil	

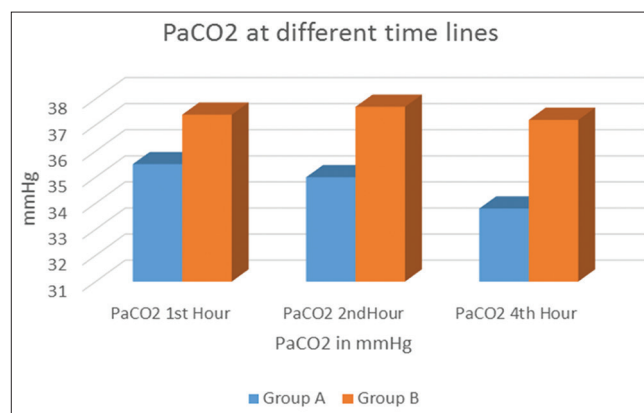


Figure 1: Bar Diagram showing PaCO₂ levels at 1, 2, and 4 hours between two groups

is entirely flushed out of the airway. High flows nasal oxygen enters nose at 70-90 L/min loops around the soft palate, exits via the mouth, and create highly turbulent “primary supraglottic vortex” that constantly replenish pharynx with oxygen preventing entrainment of room air. This vortex bypasses 50% of the resistance of the entire respiratory system. These high flows which are humidified and warmed generate positive airway pressure reducing airway collapsibility and distal airway atelectasis. Apnoeic ventilation is a result of interaction between primary supraglottic vortex from above and cardiogenic oscillations from below. Cardiogenic oscillations from compression and expansion of small airways by blood leaving and entering the thoracic cavity with each beat. The amplitude of cardiogenic breath is 7–15 ml/beat. With THRIVE, this volume is flushed into supraglottic vortex during cardiogenic expiration is removed and replaced by 100% oxygen. Cardiogenic inspiration moves oxygen towards distal airways and entrains turbulence by enhancing intratracheal mixing.^[11]

Hernandez *et al.* found reintubation in low-risk patients were lesser in high flows group when compared to nasal oxygenation (4.9% vs 12.2%, $P = 0.004$) with no adverse effects noted in high flows group.^[12] Similarly, in the present study, no adverse effects were seen in the high flows group.

A meta-analysis by Lu Z chang *et al.* showed a significant decrease in reintubation rate ($p < 0.0001$) with no difference in the incidence of postoperative complications ($p = 0.21$) or mortality ($p = 0.14$) in high flows group compared to conventional nasal oxygen in adult postoperative patients.^[13] Even in the current study, the authors found no difference in mortality between the two groups. Another metanalysis by Zhu *et al.* in cardiac surgical patients concluded that high flows can be safely administered with a reduction in need of escalation of respiratory support ($p < 0.001$) but without significant difference in reintubation rate ($p = 0.98$).^[14]

V. Zochios *et al.* studied the role of the prophylactic and therapeutic use of high flows in cardiac surgical patients at a high risk of respiratory complications. They found decreased hospital length of stay ($p = 0.012$) and ICU readmission ($p = 0.026$) in high flows group.^[15] This explains the vital role of high flows after extubation in high-risk cases.

Gustaffson *et al.* explained the importance of THRIVE during apnoeic oxygenation under general anesthesia to extend the apnoeic window period.^[16] Therefore, the authors of the present study utilized THRIVE in

post-extubation and found a significant decrease in paco₂ at different time points ($p = 0.022$, $P = 0.002$, $P < 0.001$) in comparison with conventional nasal oxygenation.

Lodenus *et al.* described potential benefits of oxygenation with THRIVE for rapid sequence intubation along with partial washout of CO₂.^[17] In contrast, the authors of the present study utilized THRIVE the following extubation to study changes in paco₂ and oxygenation with comparison to nasal oxygenation.

Maggiore *et al.* utilized high flows versus venturi mask following extubation and found a potential role of high flows in better oxygenation ($p = 0.03$), reduction in paco₂, and better comfort ($p = 0.002$). This realized the importance of high flows following extubation.^[18] The authors of the present study found pao₂ in the THRIVE group being significantly higher ($p < 0.001$) along with a significant reduction in paco₂ statistically.

Zarbock *et al.* studied the role of prophylactic nasal CPAP following cardiac surgery and found improved pao₂/fio₂ with decreased reintubation rates ($p = 0.03$).^[19] In similar lines, the authors of the current study used THRIVE in comparison with nasal oxygenation following extubation in cardiac surgery.

In our study, the authors compared THRIVE versus conventional nasal oxygenation concerned for oxygenation, CO₂ elimination, ventilation duration, reintubation rate, ICU stay, and mortality. There was a statistically significant higher pao₂ in group A at 1, 2, 4 hrs following extubation ($p < 0.001$). Even though paco₂ at 1, 2, 4 hrs being significantly less statistically in group A ($p = 0.022$, 0.02 , <0.001), it does not have clinical significance This might be probably because of the study being carried in patients without respiratory compromise. This effect has to be studied on respiratory compromised ones to know accurately about CO₂ elimination. Ventilation duration ($p = 0.061$) and sedation scores ($p = 0.499$) were comparable between the two groups. There were no incidences of reintubation and mortality in the two groups. Since pre-existing respiratory pathology patients and emergency cases were excluded, the ICU stay might not have shown any difference between the two groups ($p = 0.67$).

Limitations

Since the study was conducted in elective patients by excluding those with previous respiratory pathology, the importance of CO₂ elimination with better oxygenation could not be assessed accurately.

CONCLUSION

We conclude that THRIVE has a potential role in oxygenation and it is safe to use in adult cardiac surgery after extubation.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Cueva LF, Bausili M, González R, Ardila C, Galán J. Postoperative pulmonary complications in cardiac surgery patients: A prospective cohort, single-centre study. *Eur J Anaesth* 2014;31-80.
- Gravlee GP. *Cardiopulmonary Bypass: Principles and Practice*. Lippincott Williams & Wilkins; 2008.
- Sabaté S, Mazo V, Canet J. Predicting postoperative pulmonary complications: Implications for outcomes and costs. *Curr Opin Anesthesiol* 2014;27:201-9.
- Wynne R, Botti M. Postoperative pulmonary dysfunction in adults after cardiac surgery with cardiopulmonary bypass: Clinical significance and implications for practice. *Am J Crit Care* 2004;13:384-93.
- Dysart K, Miller TL, Wolfson MR, Shaffer TH. Research in high flow therapy: Mechanisms of action. *Respir Med* 2009;103:1400-5.
- Wagstaff TA, Soni N. Performance of six types of oxygen delivery devices at varying respiratory rates. *Anaesthesia* 2007;62:492-503.
- Nishimura M. High-flow nasal cannula oxygen therapy in adults. *J Intensive Care* 2015;3:15.
- Lee JH, Rehder KJ, Williford L, Cheifetz IM, Turner DA. Use of high flow nasal cannula in critically ill infants, children, and adults: A critical review of the literature. *Intensive Care Med* 2013;39:247-57.
- Cuquemelle E, Pham T, Papon JF, Louis B, Danin P-E, Brochard L. Heated and humidified high-flow oxygen therapy reduces discomfort during hypoxemic respiratory failure. *Respir Care* 2012;57:1571-7.
- Itagaki T, Okuda N, Tsunano Y, Kohata H, Nakataki E, Onodera M, *et al.* Effect of high-flow nasal cannula on thoraco-abdominal synchrony in adult critically ill patients. *Respir Care* 2014;59:70-4.
- Hermez L, Spence C, Payton M, Nouraei S, Patel A, Barnes T. A physiological study to determine the mechanism of carbon dioxide clearance during apnoea when using transnasal humidified rapid insufflation ventilatory exchange (THRIVE). *Anaesthesia* 2019;74:441-9.
- Hernández G, Vaquero C, González P, Subira C, Frutos-Vivar F, Rialp G, *et al.* Effect of postextubation high-flow nasal cannula vs conventional oxygen therapy on reintubation in low-risk patients: A randomized clinical trial. *JAMA* 2016;315:1354-61.
- Lu Z, Chang W, Meng S-S, Zhang X, Xie J, Xu J-Y, *et al.* Effect of high-flow nasal cannula oxygen therapy compared with conventional oxygen therapy in postoperative patients: A systematic review and meta-analysis. *BMJ Open* 2019;9:e027523.
- Zhu Y, Yin H, Zhang R, Wei J. High flow nasal cannula oxygen therapy versus conventional oxygen therapy in cardiac surgical patients: A meta-analysis. *J Crit Care* 2017;38:123-8.
- Zochios V, Collier T, Blanduszyn G, Butchart A, Earwaker M, Jones N, *et al.* The effect of high-flow nasal oxygen on hospital length of stay in cardiac surgical patients at high risk for respiratory complications: A randomised controlled trial. *Anaesthesia* 2018;73:1478-88.
- Gustafsson I-M, Lodenius Å, Tunelli J, Ullman J, Jonsson Fagerlund M. Apnoeic oxygenation in adults under general anaesthesia using Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE)-A physiological study. *Br J Anaesth* 2017;118:610-7.
- Lodenius Å, Piehl J, Östlund A, Ullman J, Jonsson Fagerlund M. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) vs. facemask breathing pre-oxygenation for rapid sequence induction in adults: A prospective randomised non-blinded clinical trial. *Anaesthesia* 2018;73:564-71.
- Maggiore SM, Idone FA, Vaschetto R, Festa R, Cataldo A, Antonicelli F, *et al.* Nasal high-flow versus Venturi mask oxygen therapy after extubation. Effects on oxygenation, comfort, and clinical outcome. *Am J Respir Crit Care Med* 2014;190:282-8.
- Zarbock A, Mueller E, Netzer S, Gabriel A, Feindt P, Kindgen-Milles D. Prophylactic nasal continuous positive airway pressure following cardiac surgery protects from postoperative pulmonary complications: A prospective, randomized, controlled trial in 500 patients. *Chest* 2009;135:1252-9. Published online 2008 Nov 18. doi: 10.1378/chest.08-1602.