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Original Article

Clinical Analysis of Transnasal Humidified Rapid Insufflation Ventilatory Exchange for Geriatrics during Gastrointestinal Endoscopy

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SUMMARY

Objective: To compare the oxygenation level and clinical effect of THRIVE at different flow rates and nasal catheter ventilation in geriatrics undergoing painless gastrointestinal endoscopy.
Methods: This study involved geriatrics undergoing painless digestive endoscopy at Shenzhen Hospital (Futian) of Guangzhou University of Traditional Chinese Medicine from January to December 2023. Participants were randomly divided into three groups: N (nasal catheter, 60 cases), Th1 (THRIVE 10L, 60 cases), and Th2 (THRIVE 20L, 60 cases). SpO2, MAP, and HR were measured at T0 (pre-induction), T1 (5 min after induction), T2 (during operation), and T3 (post-operation). Safe apnea time, mechanical ventilation rate, respiratory depression rate, satisfaction, recovery time, and incidence of adverse reactions like dizziness, nausea, and vomiting were also recorded.
Results: There were no significant differences in HR and MAP across groups ($p > 0.05$). SpO2 was higher in Th1 and Th2 groups than in N group at T1, with Th2 showing the highest levels at T1, T2, and T3 ($p < 0.05$). Th1 and Th2 groups had longer safety time, lower mechanical ventilation, respiratory depression rates and lower patients' satisfaction compared to N group ($p < 0.05$). Recovery time was shorter in Th1 and Th2, with no difference in doctor satisfaction between groups ($p > 0.05$). There were no significant differences in nausea, vomiting, or postoperative dizziness ($p > 0.05$).
Conclusion: THRIVE for geriatrics undergoing gastrointestinal endoscopy can not only improve the oxygenation state, but also effectively reduce the incidence of respiratory depression and mechanical ventilation, shorten the recovery time, and decrease the rate of postoperative nausea and vomiting. This method may provide convenience for anesthesiologists in the intraoperative management.

1. Introduction

Gastrointestinal endoscopy is a critical tool for clinical diagnoses and treatment of digestive system diseases. With the proposal of the "Comfort Diagnostic and Therapeutic Procedure" concept as well as its continuous development, painless gastrointestinal endoscopy develops gradually and become the first choice for patients with digestive diseases.[1] Painless gastrointestinal endoscopy is highly recommended as it can comfort patients by relieving their anxiety and fear of endoscopic examination, thus increasing their compliance of examination.[2] Hypoxemia is one of the most common complications in painless gastrointestinal endoscopy (GI endoscopy).[3] For geriatrics with reduced tolerance, there may be more prominent unexpected consequences of hypoxia, including severe cerebrovascular disease.[4] Transnasal humidified rapid insufflation ventilation exchange (THRIVE) can transmit high flow gases through the nasal catheter. With the advantage of heating and humidifying gases voluntarily, use of THRIVE can maintain the clearance function of the ciliary mucus system, positive pressure ventilation,[5] reduce the physiological invalid cavity, produce positive end expiratory pressure, and promote the expansion of end respiratory alveoli.[6] It is of great significance for the treatment of patients with respiratory diseases such as respiratory failure, postoperative atelectasis, respiratory distress, etc.[7] However, so far, there are few reports on the application of THRIVE at different flow rates in painless GI endoscopy for geriatrics. Accordingly, this study aims to observe the application effect of THRIVE at different oxygen flow rates in painless GI endoscopy for geriatrics, so as to seek a safer respiratory tract management scheme.

2. Materials and methods

2.1. General data

This study included geriatrics undergoing painless GI endoscopy or colonoscopy at Shenzhen Hospital (Futian) of Guangzhou University of Traditional Chinese Medicine (TCM) from January to December 2023. Inclusion criteria: males and females over 65 years, BMI < 30 kg/m^2, ASA grades I-III. Exclusion criteria: mental illness, allergies to propofol, soy, or egg, upper respiratory diseases, coagulation dysfunction, serious heart/lung/liver/kidney diseases, or conditions like intra-gastric hypertension, intestinal obstruction, or intracranial hypertension. Patients with anesthesia changes or loss to follow-up

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were also excluded. All participants underwent outpatient anesthesia evaluation and provided informed consent. This study was approved by the Ethics Committee of Shenzhen Hospital (Futian) of Guangzhou University of TCM (KS-2024292-1).

2.2. Grouping and intervention

A total of 180 patients were divided into three groups by the anesthesiologists who did not participate in this study according to the random number table generated by SPSS 21.0. The specific groups were: nasal catheter oxygen inhalation group (N Group), THRIVE oxygen inhalation 10L group (Th1 group) and THRIVE oxygen inhalation 20L group (Th2 group). Patients from the three groups were examined by GI endoscopy or electronic colonoscopy without pain. Patients from Th1 and Th2 groups were provided with nasal humidification high flow ventilation therapy apparatus (Guangzhou Jingke Medical Technology Co., Ltd.), with the oxygen flow rate set at 10l/min and 20l/min, the oxygen concentration at 40%, and the temperature at 37 °C. In N group, the traditional nasal catheter was used for oxygen therapy, and the oxygen flow rate was adjusted to 4–5 l/min to ensure that the initial oxygen concentration (fio2 = 0.21 + 0.04 * oxygen flow rate) was the same as that of Th1 group and Th2 group. All researchers participated in this study had been qualified after standardized training of THRIVE. The examination, anesthesia and follow-up recording were respectively completed by the same endoscopist, anesthesiologist and the same person, respectively. Special attention was paid to the changes of vital signs and breathing conditions of the elderly intraoperatively.

2.3. Anesthesia method

Patients were told to fast for 8 hours and liquid fast for 2 hours before operation. According to the digestive endoscopy diagnosis and treatment guidelines, 30 ml of defoamer and 10 ml of dyclonine hydrochloride mucilage were respectively orally administered 30 min and 10 min before the examination.[8] After entering the room, patients were subjected to establishment of the peripheral venous access, adjustment of the left lateral decubitus position, monitoring of blood pressure (BP), electrocardiogram (ECG), SpO_2 value and Narcotrend monitoring. The THRIVE device was heated and humidified 5 min before use. Patients in Th1 and Th2 groups were connected to THRIVE (Fisher & Payke, New Zealand) for oxygen inhalation, and the flow rates were 10 L and 20 L/min, respectively. Patients in N group received oxygen inhalation through nasal cannula at the oxygen flow rate of 5–6 l/min. The anesthesia induction program of all patients was: propofol 2 mg/kg, remifentanil 0.4 μg/kg, intravenous injection of induction drugs after calm breathing for 3 min. The endoscopic operation was finished by the same endoscopist when the patient was observed with disappeared consciousness and eyelash reflex, slow and stable breathing, and the depth of anesthesia reaching NT stage d0–d1 (NT value 64–47). Propofol 0.2–0.5 mg/kg and remifentanil 0.2–0.5 μg/kg were appropriately added intraoperatively according to the stimulation intensity and operation time, combined with the patient's breathing, heart rate (HR) changes and body movement. This study recorded and adopted suitable treatment for hypoxia related adverse events according to the recommended guidelines of the international sedation working group of the Society of Intravenous Anesthesia.[9] Details are introduced as follows: (1) subjective judgement of the occurrence of adverse events or not by the anesthesiologist, and entering step 2 in case of occurrence; (2) description of hypoxia related adverse reactions: subclinical respiratory depression ($90\% \leq SpO_2 < 95\%$); Hypoxia ($75\% \leq SpO_2 < 90\%$, < 60s); severe hypoxia ($SpO_2 < 75\%$ or < 90% for > 60s). (3) interventions: for patients with $SpO_2 < 95\%$ started intervention: ① stop medication; ② supporting the jaw to open the airway; ③ when SpO_2 was less than 90%, stop GI endoscopy, apply the mask to pressurize oxygen, and place the nasopharyngeal airway if necessary; and ④ place an endoscopic laryngeal mask airway if the above treatment failed, with the implementation of endotracheal intubation and mechanical ventilation when necessary. Atropine were used to maintain HR at 50–90 beats/min intraoperatively. M-hydroxylamine was used to stabilize BP fluctuation and keep it within 20% of preoperative measurement. Postoperative follow-up was performed by another doctor who was not involved in the anesthesia procedure. Doctor responsible for the follow-up was not informed of the patient's interventions.

2.4. Outcome measures

This study conducted comparative analyses among the three groups on the following outcome measures: 1. the time of gastrointestinal endoscopy and the doses of propofol and remifentanil; 2. the changes of vital signs SpO_2, HR, MAP of the three groups at different time points. Blood oxygen, MAP and HR were measured before induction (T0), 5 min after induction (T1), during operation (T2) and after operation (T3); 3. the safe apnea time (the time from the first intravenous injection of propofol to $SpO_2 < 90\%$), mechanical ventilation rate (number of mechanical ventilation/total number of patients in the group) and respiratory depression rate; 4. the satisfaction and recovery time of the three groups of patients and examiners; 5. the incidence of postoperative dizziness, nausea, vomiting and other adverse reactions of the three groups.

2.5. Statistic analysis

Graph plotting and statistical analyses were performed using GraphPad Prism 9.0 and SPSS 22.0. Quantitative data are presented as the mean ± SD ($X \pm SD$). Data from multiple time points were compared using Repeated Measures ANOVA, and comparisons among the three groups were made using the One-way ANOVA and Tukey's HSD. Counting data were expressed as the number of cases or per-

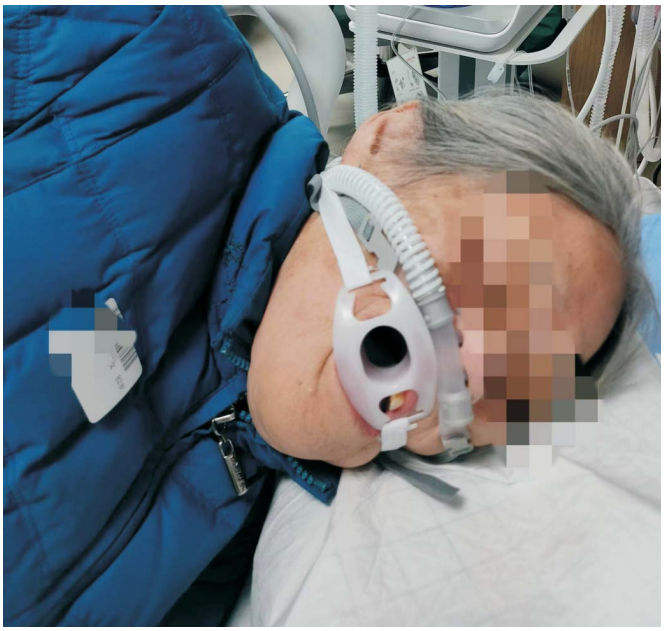

Figure 1. Geriatric undergoing THRIVE.

centage, and the inter-group comparison was performed using χ^2 test. $p < 0.05$ was considered indicative of a statistically significant difference.

3. Results

A total of 80 subjects participated in the study, all of whom completed the entire ESPB experiment.

3.1. Comparison of baseline data among the three groups

As shown in Table 1, there was no significant difference in age, gender, height, weight, ASA grade, and other baseline data among the three groups ($p > 0.05$) (Table 1).

3.2. Comparison of the time of gastrointestinal endoscopy as well as the doses of propofol and remifentanil among the three groups

There was no significant difference in dosage of intravenous injection of propofol and remifentanil among the three groups ($p > 0.05$) (Table 2).

3.3. Comparison of changes of vital signs of the three groups at different time points

Blood oxygen, MAP and HR were measured before induction (T0), 5 min after induction (T1), during operation (T2) and after operation (T3).

There was no statistical difference in the comparison of vital signs such as HR and MAP ($p > 0.05$). There was no statistical difference in SpO_2 among the three groups at T0. At T1, SpO_2 was higher in Th1 and Th2 groups compared with N group ($p < 0.05$), with higher level in Th2 group than that in Th1 group ($p < 0.05$). At T2, there was no significant difference between Th1 and N groupa (p 0.05), but SpO_2 was higher in Th2 group than Th1 and N groups ($p < 0.05$). At T3 and T2, there was no statistical difference between Th1 and N groups ($p > 0.05$), and SpO_2 was higher in Th2 group than Th1 and N groups ($p < 0.05$).

Further pairwise comparison revealed similar results between N group and Th1 group. Compared with T0, MAP and SpO_2 at T1 were statistically different ($p < 0.05$), while there was no statistical difference at T2 and T3 ($p > 0.05$). In Th2 group, SpO_2 and T0, T1 at T3 were statistically different ($p < 0.05$). There was no significant difference in HR between groups from T0 to T3 ($p > 0.05$) (Table 3).

3.4. Comparison of the safe apnea time, mechanical ventilation rate and respiratory depression rate among the three groups

By one way ANOVA, there were significant differences in the

Table 2
Comparison of operative time, propofol, and remifentanil between three groups ($x \pm s$).

Group	Number	Operative time	Propofol	Remifentanil
N group	60	20.63 ± 8.93	140.15 ± 11.25	26.50 ± 3.48
TH_1 group	60	20.77 ± 10.19	139.65 ± 11.54	26.00 ± 3.73
TH_2 group	60	22.05 ± 10.16	138.93 ± 11.82	26.28 ± 3.86
F value		0.353	0.169	0.277
p value		0.703	0.845	0.759

Table 1
Comparison of general information between three groups of patients.

Group	Number	Gender (male/female)	ASA[a] (II/III)	Age (years)	Height (m)	Weight (kg)
N group	60	21/39	6/54	78.2 ± 8.56	158.3 ± 8.02	58.2 ± 11.32
TH_1 group	60	24/36	8/52	77.8 ± 9.29	158.6 ± 8.34	57.7 ± 11.15
TH_2 group	60	20/40	9/51	78.6 ± 9.26	157.75 ± 8.56	56.5 ± 10.97
F value		0.309	0.345	0.143	0.099	0.369
p value		0.734	0.709	0.867	0.906	0.692

[a] ASA: American Society of Anesthesiologists Classification.

Table 3
Comparison of changes in vital signs between three groups at different time points ($x \pm s$)

Group	Number	MAP (mmHg)	HR (beats/min)	SO_2 (%)
N group	60			
T0		103.87 ± 13.13	76.85 ± 16.35	95.05 ± 3.16
T1		79.72 ± 11.98[a]	78.33 ± 13.89	87.35 ± 5.97[a,b]
T2		102.72 ± 13.09	76.32 ± 13.37	93.82 ± 2.28
T3		102.10 ± 12.82	76.68 ± 13.60	93.98 ± 2.27
TH_1 group	60			
T0		102.73 ± 13.46	77.78 ± 15.07	94.85 ± 3.17
T1		80.67 ± 11.83[a]	76.50 ± 15.66	90.70 ± 3.91[a,b]
T2		102.10 ± 12.82	72.60 ± 14.68	94.28 ± 2.95[b]
T3		102.85 ± 13.08	73.72 ± 13.27	94.35 ± 2.98[b]
TH_2 group	60			
T0		104.20 ± 12.94	75.15 ± 15.59	94.88 ± 3.02
T1		81.13 ± 12.16[a]	76.85 ± 13.59	94.83 ± 3.28[b]
T2		102.85 ± 13.08	72.92 ± 15.80	95.92 ± 2.63[b]
T3		102.32 ± 13.18	76.75 ± 14.59	96.50 ± 2.29[a,b]
F-time, P-time		137.4, < 0.0001	1.67, 0.17	62.56, < 0.0001
F-interblock, P-interblock		0.13, 0.87	1.15, 0.32	50.73, < 0.0001
F-interactive, P-interactive		0.12, 0.99	0.52, 0.79	14.48, < 0.0001

Note: Compared with T0 in this group, [a] $p < 0.05$; Compared with the control group during the same period, [b] $p > 0.05$; HR: heart rate; MAP: mean arterial pressure; SO2: blood oxygen saturation; 1 mm Hg = 0.133 k Pa.

comparison of the safe apnea time, mechanical ventilation rate and respiratory depression rate of the three groups. Compared with N group, the safe apnea time of patients was longer, while the mechanical ventilation and respiratory depression rates were lower and in Th1 and Th2 groups (all $p < 0.05$). Compared with Th1 group, the safe apnea time was longer, while the mechanical ventilation and respiratory depression rates were lower in Th2 group (all $p < 0.05$) (Table 4).

3.5. Comparison of the satisfaction and recovery time of patients and examiners in the three groups

By one-way ANOVA, significant differences were detected in the patient satisfaction and recovery time of the three groups. Compared with N group, patients' satisfaction was lower, the recovery time was shorter, and the mechanical ventilation rate was lower in Th1 and Th2 groups (all $p < 0.05$). There was no significant difference in patient satisfaction between Th2 and Th1 groups ($p > 0.05$); the recovery time was shorter ($p < 0.05$). There was no significant difference in the satisfaction of examination doctors among the three groups ($p > 0.05$) (Table 5).

3.6. Comparison of the incidences of postoperative dizziness, nausea, vomiting and other adverse reactions among the three groups

By one-way ANOVA, there was statistical difference in the comparison of the incidence of postoperative dizziness among the three groups ($p < 0.05$). Compared with N group, the postoperative dizziness of Th1 and Th2 groups was lower, without significant intergroup difference ($p > 0.05$). In addition, no significant difference was observed in the incidence of nausea and vomiting among the three groups ($p > 0.05$) (Table 6).

4. Discussion

The elderly aged 65 and older accounted for 70% of patients with digestive system tumors, suggesting their greater demand for gastrointestinal endoscopy.[10] With the popularization of the "Comfort Diagnostic and Therapeutic Procedure" concept, painless GI endoscopy has gradually become a recommended examination. However, age was reported to be an independent risk factor for complications (hypoxemia in particular) of painless GI endoscopy.[11]

In order to improve the comfort and acceptance of geriatrics undergoing gastrointestinal endoscopy, and reduce relevant complications, it is particularly critical to find a safe and effective oxygen therapy method. THRIVE device can provide high-concentration oxygen (21%–100%) with heating (31 °C to 37 °C), humidification and high flow rate (0–70 l/min), thus effectively improving the oxygenation status of patients.[5,7] According to existing data, THRIVE device has a good effect in pre-oxygenation, and can prolong the safe apnea time of geriatrics during general anesthesia induction.[12] In addition, THRIVE device ensures adequate oxygenation of patients during endoscopic retrograde cholangiopancreatography under sedation anesthesia, and provides reference and guidance of ventilation strategy for other endoscopic examinations under sedation anesthesia.[13]

In this study, geriatrics undergoing painless gastrointestinal endoscopy occurred respiratory depression frequently in different degrees. The incidence of respiratory depression was 31.7% in patients receiving nasal tube oxygen inhalation. Compared with the nasal tube oxygen inhalation group, the incidence of hypoxia related adverse events and intervention measures were significantly reduced in THRIVE group, and only 7 cases (11.7%) and 2 cases (3.3%) of subclinical respiratory depression occurred in the Th1 and Th2 groups, respectively. The safe apnea time of THRIVE group was also much longer than that of nasal tube oxygen inhalation group, and the average safe apnea time of Th2 group was as high as 25.33 seconds. Furthermore, no patients (0%) in Th1 and Th2 groups received mechanical ventilation, while 2 patients (3.3%) in N group received mechanical ventilation. By jaw lifting to assist in opening the airway, the patient's oxygenation was improved without hypoxia.

THRIVE can provide high and stable concentration and flow of inspired oxygen. Through the scouring effect of high flow and high concentration of oxygen, there would be a significant reduction in the anatomical dead space of nasopharynx, thereby avoiding repeated inhalation of high concentration carbon dioxide (CO_2) and low concentration oxygen (O_2), and effectively optimizing the oxygenation effect. In addition, the pressure of the nasopharynx would be increase by 1 cmH_2O for every 10 l/min increase in the gas flow of the nasopharynx. In this study, the dynamic positive airway pressure produced by THRIVE ranged between 2.7–7.4 cmH_2O. It would be conducive to increasing the end expiratory lung volume, maintaining the open state of alveoli, thus promoting blood gas exchange and further improving the oxygenation level of patients. THRIVE can provide continuous positive airway pressure and a certain value of PEEP. Joseph et al.[14] showed that THRIVE was equivalent to nasal bi-level positive airway pressure ventilation (N/BiPAP) in maintaining gas exchange, with fewer complications than n/BiPAP. Doshi et al.[15] showed that PEEP generated by THRIVE showed a quadratic relationship with the HFNC flow rate setting. It allowed THRIVE to effectively promote end respiratory lung recruitment in older patients, increase end respiratory alveolar volume, improve lung ventilation, and improve

Table 4
Comparison of safety period, mechanical ventilation rate and respiratory depression rate among three groups.

Group	Number	safety period	Mechanical ventilation rate (%)	Respiratory depression rate (%)
N group	60	3.00 ± 1.43	3.3%	31.7%
TH_1 group	60	12.68 ± 4.53	0.0%	11.7%
TH_2 group	60	25.33 ± 2.84	0.00%	3.3%
F value		736.6	548.3	681.7
p value		< 0.0001	< 0.0001	< 0.0001

Table 5
Comparison of patient satisfaction, surgeon satisfaction and wake-up time among three groups.

Group	Number	Patient satisfaction	Satisfaction of operating doctors	Wake-up time
N group	60	97.28 ± 1.66	91.45 ± 2.25	14.92 ± 3.19
TH_1 group	60	88.96 ± 5.48	91.40 ± 3.12	12.20 ± 2.88
TH_2 group	60	87.98 ± 5.61	90.57 ± 5.74	6.02 ± 2.64
F value		73.28	0.91	147.2
p value		< 0.0001	0.406	< 0.0001

Table 6
Comparison of the incidences of postoperative dizziness, nausea, vomiting and other adverse reactions among the three groups.

Group	Number	Postoperative dizziness	Nausea and vomiting
N group	60	25	11
TH_1 group	60	8	9
TH_2 group	60	5	10
F value		73.28	0.91
p value		< 0.0001	0.508

oxygenation consequently. In addition, THRIVE can reduce the diaphragmatic load and respiratory work during respiratory exercise in geriatric.[16]

Furthermore, compared with nasal tube oxygen inhalation group, the incidence of adverse events unrelated to hypoxia, such as prolonged awakening time, postoperative nausea and vomiting, was significantly reduced in THRIVE group, with lower patient satisfaction. The length of postoperative recovery time directly affected the recovery process of patients. In this study, patients in THRIVE group had significantly shorter awakening time on average than those in the conventional oxygen therapy group, which may be attributed primarily to more effective oxygenation support provided by THRIVE. THRIVE can continuously provide heated and humidified high-concentration oxygen under high flow rate, thereby significantly improving the oxygenation state of patients. On the basis of such continuous high oxygen flow, it enables the reduction of the occurrence of postoperative hypoxemia and avoiding multiple organ dysfunction or hypoxia-induced delayed recovery. The decreased incidence of adverse events unrelated to hypoxia in THRIVE group may be explained by many factors, such as better oxygenation, airway management and drug metabolism. Lower patient satisfaction with THRIVE may stem from high self-paid costs. Additionally, patients may have high expectations but cannot perceive benefits under anesthesia, making cost and expectation management key factors in their dissatisfaction.

This study has several limitations. The small sample size may affect statistical significance and generalizability. Lack of follow-up data prevents assessment of long-term effects and complications, limiting safety understanding. The single-center design reduces external validity, and without considering individual differences in geriatrics, the adaptability of THRIVE could be impacted. Future research should address these issues by increasing sample size, extending follow-up, including multiple centers, and accounting for individual variations to better assess THRIVE's clinical value.

In conclusion, THRIVE in geriatrics undergoing gastrointestinal endoscopy enhances oxygenation, reduces respiratory depression, and accelerates recovery. It lowers postoperative nausea and vomiting and simplifies anesthesiologist management, highlighting its clinical benefits for this patient group.

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Conflict of interest declaration

All authors declare no personal or professional conflicts of interest relating to any aspect of this study.

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