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Application of transnasal humidified rapid-insufflation ventilatory exchange in intravenous anesthesia of obese patients undergoing hysteroscopic surgery

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Abstract: **Objective** To observe the application effect of transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) during intravenous anesthesia for hysteroscopy in obese patients, as well as the incidence of adverse reactions. **Methods** A total of 100 obese patients undergoing elective hysteroscopy at the Affiliated Hospital of Nanjing University of Chinese Medicine from January to December 2024 were selected. They were randomly divided into the observation group and the control group (*n*=50, each) using a random number table method. The observation group received THRIVE, while the control group was given conventional nasal cannula oxygen inhalation. Both groups were anesthetized with intravenous injection of propofol (1.5-2.5 mg/kg) combined with intravenous injection of sufentanil (0.1 μg/kg). General vital signs and arterial blood gas indicators were compared between the two groups at three time points: before anesthesia (T0), 5 minutes after anesthesia (T1), and 5 minutes after awakening (T2). The incidenceand management of hypoxia-related adverse events, main anesthetic indicators (awakening time, dosages of propofol and sufentanil), and occurrence of adverse reactions were recorded. **Results** At T1, the mean arterial pressure and heart rate in the observation group were lower than those in the control group, while the saturation of peripheral oxygen was higher (P<0.05); there was no statistically significant difference in vital signs between the two groups at other time points ((P>0.05). The incidence of hypoxia-related adverse events in the observation group was lower than that in the control group (subclinical respiratory depression: 12.0% *vs* 44.0%, χ^2 =12.689, P<0.01; hypoxia: 2.0% *vs* 18.0%, χ^2 =7.111, P= 0.008). Additionally, the concurrent usage rate of open airway techniques and face masks in the observation group were also lower than those in the control group (12.0% *vs* 68.0%, χ^2 =32.667, P<0.01; 0 *vs* 12.0%, χ^2 =12.636, P<0.01). At T2, (the arterial partial pressure of oxygen and arterial oxygen saturation in the observation group were significantly higher; there was no statistically significant difference in pH value or arterial partial pressure of carbon dioxide between the two groups (P>0.05). No significant difference in arterial blood gas indicators was found between the two groups at other time points (P>0.05). There was no statistically significant difference in the total incidence of adverse reactions between the control group and the observation group [10.0% (5/50) *vs* 10.0% (5/50), χ^2 =0, P=1.000]. **Conclusion** In obese patients undergoing hysteroscopic surgey, THRIVE can effectively prevent hypoxia-related adverse events during anesthesia and reduce the need for airway support.

Keywords: Transnasal humidified rapid-insufflation ventilatory exchange; Hysteroscop; Obesity; Hypoxia; Propofol; Sufentanil; General anesthesia

Hysteroscopic surgery is a widely used minimally invasive gynecological diagnosis and treatment technology in current clinical practice, with advantages including visualization, minimal bleeding, rapid recovery, and short hospital stay [1]. Current domestic expert consensus recommends monitored anesthesia care (MAC) as the standard anesthesia management regimen for hysteroscopic surgery [1]. Commonly used intravenous anesthetics and opioids in clinical practice may lead to a high incidence of respiratory depression and intraoperative hypoxemia, which is particularly prominent in the obese patient population. Physiological changes in obese patients, such as reduced pulmonary compliance and decreased functional residual capacity caused by chest and abdominal fat accumulation, further increase the risk of hypoxemia, and may even require conversion to endotracheal intubation under general anesthesia in severe cases [2]. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE), as a modified high-flow oxygen therapy technology with no apneic oxygenation effect, has attracted extensive attention and research in the field of anesthesiology [3-6]. Previous clinical studies have observed that the THRIVE technology can significantly reduce the risk of hypoxia-related adverse events during intravenous anesthesia for minimally invasive breast excisional biopsy, thereby reducing the need for airway support and improving perioperative safety of patients [7]. This study aims to explore the application value of the THRIVE technology in the perioperative period of intravenous anesthesia for hysteroscopic surgery in obese patients, and systematically evaluate its safety and efficacy.

1 Materials and Methods

1.1 Clinical Data

This study was approved by the Ethics Committee of the Affiliated Hospital of Nanjing University of Chinese

Medicine (Ethics Approval No.: 2023NL-109-02), and informed consent was signed by all patients. The study was conducted from January 2024 to December 2024, and the subjects were obese female patients who underwent elective hysteroscopic surgery at Jiangsu Province Hospital of Chinese Medicine.

Inclusion criteria: (1) Age between 18 and 60 years old; (2) American Society of Anesthesiologists (ASA) physical status classification grade I-II; (3) Body mass index (BMI) ≥30 kg/m².

Exclusion criteria: (1) Inability to cooperate with or tolerate the THRIVE technique; (2) History of mental illness or long-term sedative use; (3) Presence of airway protective dysfunction or high risk of aspiration (such as upper gastrointestinal obstruction); (4) Allergy to propofol; (5) Severe obstructive sleep apnea syndrome.

The study subjects were randomly divided into an observation group and a control group using a random number table method, with 50 cases in each group. The observation group received THRIVE for oxygen administration, while the control group received conventional nasal cannula oxygen therapy. There was no statistically significant difference in age, BMI, and ASA classification between the two groups (P>0.05), as shown in **Table 1**.

Tab.1 Comparison of general data between two groups (n=50, $\bar{x}\pm s$)

Group	Age (years)	BMI (kg/m²)	ASA classification (I/II, n)
Control group	32.2±4.5	35.3±2.2	32/18
Observation group	31.3±4.2	34.8±2.0	30/20
t/χ^2 value	1.034	1.189	0.217
P value	0.304	0.237	0.641

1.2 Anesthesia Methods

1.2.1 Preoperative Preparation

All patients fasted for 8 hours and prohibited drinking for 2 hours before surgery. After entering the operating room, routine electrocardiographic monitoring was performed and intravenous access was established. For intraoperative oxygen therapy regimens, all patients received preoxygenation for 5 minutes. The control group received oxygen via bilateral nasal cannula with humidification through a humidifier bottle at an oxygen flow rate of 8 L/min. The observation group received pure oxygen through a high-flow humidifier (Fisher & Paykel Healthcare, New Zealand) at an oxygen flow rate of 8 L/min and a temperature of 37 °C, which was adjusted to 50 L/min after the patient lost consciousness. Total intravenous anesthesia was used for both groups. Propofol (Yingke Biopharmaceutical, Jiangsu, National Medicine Approval No. H20223914) 1.5–2.5 mg/kg was intravenously injected combined with sufentanil (Yichang Humanwell Pharmaceutical, National Medicine Approval No. H20205068) 0.1 μg/kg by intravenous bolus. During the operation, propofol was continuously infused intravenously at 3–5 mg/(kg·h), and the dosage of anesthetics was appropriately supplemented based on the patient's intraoperative vital signs and surgical responses. Propofol infusion was stopped at the end of the surgery.

1.2.2 Intraoperative Management

For subclinical respiratory depression [saturation of peripheral oxygen (SpO_2) 90% to<93%], the jaw-thrust maneuver was performed to open the airway. For hypoxia (SpO_2 75% to<90%, duration<60 s), the jaw-thrust maneuver was maintained until SpO_2>95%. For severe hypoxia (SpO_2<75% or SpO_2 75% to<90% with duration ≥60 s), the surgery was immediately stopped, and mask ventilation with pressurized oxygen was administered, followed by endotracheal intubation for mechanical ventilation if necessary. For hemodynamic management, if mean arterial pressure (MAP) decreased by 20% compared with the pre-intervention level, ephedrine (Chengdu Beite Pharmaceutical, National Medicine Approval No. H32021530) 6 mg was intravenously injected; if heart rate was<50 beats/min, atropine (Jin Yao Heping Pharmaceutical, National Medicine Approval No. H12020385) was intravenously injected.

1.3 Observation Indicators

1.3.1 General Vital Sign Indicators

Relevant indicators of general vital signs were collected from both groups, mainly including MAP, heart rate, and SpO_2 levels before anesthesia (T_0), 5 minutes after anesthesia induction (T_1), and 5 minutes after awakening (T_2).

1.3.2 Incidence of Hypoxia-related Adverse Events and Intervention Measures

Adverse event records: subclinical respiratory depression, hypoxia, and severe hypoxia. Intervention measure records: airway opening (jaw-thrust maneuver) and mask pressurized ventilation.

1.3.3 Arterial Blood Gas Indicators at Each Time Point

The arterial blood pH value, arterial partial pressure of oxygen (PaO_2), arterial partial pressure of carbon dioxide ($PaCO_2$), and arterial oxygen saturation (SaO_2) were recorded at T_0, T_1, and T_2.

1.3.4 Anesthesia Awakening Time and Dosage of Anesthetic Drugs

The anesthesia awakening time (time from the end of surgery to spontaneous eye opening of the patient) and the dosage of anesthetic drugs (total consumption of propofol and sufentanil) were recorded.

1.3.5 Occurrence of Adverse Events During the Perioperative Period

THRIVE-related complications within 30 minutes after surgery were recorded: nasopharyngeal discomfort, barotrauma; other adverse events included postoperative nausea and vomiting, regurgitation and aspiration.

1.4 Statistical Methods

SPSS 25.0 software was used for data analysis. Normally distributed measurement data were expressed as $\bar{x}\pm s$, and the t-test was used for comparison between groups. Repeated measures analysis of variance was used for multi-time point comparison, and the LSD-t test was used for pairwise comparison. Count data were expressed as case (%), and the χ^2 test was used for comparison between groups. A P value< 0.05 was considered statistically significant.

2 Results

2.1 Comparison of General Vital Signs

At the T1 time point, the MAP and heart rate of the observation group were lower than those of the control group, and the SpO_2 was higher than that of the control group (P<0.05). There was no statistically significant difference in vital signs between the two groups at other time points (P>0.05), as shown in **Table 2**.

2.2 Comparison of Arterial Blood Gas Indicators at Different Time Points Between Two Groups

There was no statistically significant difference in all arterial blood gas indicators between the two groups at the T0 and T2 time points (P>0.05). Compared with the control group, the PaO_2 and SaO_2 of the observation group at T1 were significantly higher (P<0.05), while There was no statistically significant difference in pH value and $PaCO_2$ between the two groups (P>0.05), as shown in **Table 3.**

2.3 Comparison of Hypoxia-related Adverse Events and Intervention Measures Between Two Groups

The incidence rates of subclinical respiratory depression and hypoxia in the observation group were lower than those in the control group (P<0.05). In terms of adverse event intervention measures, the incidence rates of requiring airway opening and mask ventilation in the observation group were lower (P<0.05), as shown in **Table 4**.

2.4 Comparison of Anesthesia Awakening Time and Anesthetic Dosage Between Two Groups

There was no statistically significant difference in anesthesia awakening time, total propofol dosage and total sufentanil dosage between the two groups (P>0.05), as shown in **Table 5**.

Tab.2 Comparison of MAP, heart rate, and SpO_2 between two groups at each time points (n=50, $\bar{x}\pm s$)

Group	MAP (mmHg)			heart rate (beats/min)			SpO_2 (%)		
	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2
Control group	81.2±8.5	77.3±3.2	78.5±6.1	81.6±7.8	72.3±3.5	78.5±5.2	98.2±1.2	93.1±1.4	96.6±1.3
Observation group	80.6±7.7	69.6±2.5[a]	77.3±5.7	78.4±7.6	66.5±2.8[a]	76.8±4.7	97.9±1.4	97.2±1.5[a]	97.4±1.2
$F_{time/interaction/group}$ value	38.720/10.680/20.73			99.000/3.437/30.480			120.400/73.230/98.510		
$P_{time/interaction/group}$ value	<0.001/<0.001/<0.001			<0.001/0.034/<0.001			<0.001/<0.001/<0.001		

Note: compared with the control group at the same time point, [a]P<0.05.

Tab.3 Comparison of blood gas analysis between two groups at different time points (n=50, $\bar{x}\pm s$)

Group	pH			PaO_2(mmHg)			$PaCO_2$(mmHg)			SaO_2(%)		
	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2
Control group	7.4±0.1	7.3±0.1	7.3±0.1	89.4±6.3	78.3±5.4	86.2±5.6	40.6±3.2	45.5±3.3	44.5±3.3	97.3±1.6	94.2±1.6	96.2±1.7
Observation group	7.4±0.0	7.4±0.1	7.4±0.0	87.4±5.6	182±31.3[a]	87.6±5.9	39.4±2.8	46.2±3.1	43.8±2.8	96.8±1.5	98.4±1.3[a]	96.5±1.6
$F_{time/interaction/group}$ value	4.790/1.198/0.299			314.500/470.800/462.300			94.690/2.536/1.255			7.001/62.940/53.090		
$P_{time/interaction/group}$ value	0.009/0.303/0.585			<0.001/<0.001/<0.001			<0.001/0.081/0.264			0.001/<0.001/<0.001		

Note: compared with the control group at the same time point, [a]P<0.05.

Tab.4 Comparison of hypoxia-related adverse events and interventions between two groups (n=50, $\bar{x}\pm s$)

Group	Adverse events			Intervention measures	
	Subclinical respiratory depression	Hypoxia	Severe hypoxia	Airway opening	Mask ventilation
Control group	22(44.0)	9(18.0)	3(6.0)	34(68.0)	12(24.0)
Observation group	6(12.0)	1(2.0)	0	6(12.0)	0
χ^2 value	12.689	7.111	1.370	32.667	12.636
P value	<0.001	0.008	0.227	<0.001	<0.001

Tab.5 Comparison of anesthesia emergence time and drug consumption between two groups (n=50, $\bar{x}\pm s$)

Group	Anesthesia recovery time (min)	Propofol (mg)	Sufentanil (μg)
Control group	8.8±1.6	215.5±27.5	8.5±1.6
Observation group	9.8±2.2	225.6±31.2	8.6±1.8
t value	1.149	1.717	0.294
P value	0.253	0.089	0.770

2.5 Comparison of Adverse Events Between Two groups

In the control group, there were 2 cases of nasopharyngeal discomfort and 3 cases of postoperative nausea and vomiting. In the observation group, there were 3 cases of nasopharyngeal discomfort and 2 cases of postoperative nausea and vomiting. No barotrauma or regurgitation and aspiration occurred in either group. There was no statistically significant difference in the total incidence of adverse reactions between the control group and the observation group [10.0% (5/50) *vs* 10.0% (5/50), $\chi^2=0$, $P=1.000$].

3 Discussion

Hysteroscopy is a method used for intrauterine examination and treatment, with the advantages of minimal trauma and rapid postoperative recovery [1]. Due to the need for cervical dilation during surgery, which causes significant pain, and the short duration of the procedure, most patients choose intravenous anesthesia without endotracheal intubation [1]. The use of sedative and analgesic anesthetics during anesthesia significantly increases the risk of intraoperative hypoxemia in patients. Obese patients have less oxygen reserve in the body and their airways are more prone to collapse, making them highly susceptible to hypoxemia [2]. Therefore, it is necessary to study the optimal oxygen supply method for such patients during surgery to provide a good guarantee for the smooth progress of the operation.

THRIVE is a new technology at the intersection of high-flow oxygen therapy and apneic oxygenation, and it is an apneic oxygenation technique that can replace traditional oxygen therapy [8]. It is often used in the field of critical care medicine to treat patients with severe pneumonia complicated by respiratory failure [9-10]. The THRIVE technology has high oxygen supply stability and can precisely control temperature, with a maximum flow rate of up to 70 L/min. It produces a ventilation effect through turbulence, cardiogenic oscillation, and the Haldane effect, allowing the alveoli of patients to continuously receive oxygen even in a state of apnea, and partially excrete carbon dioxide from the body. Theoretically, it can prevent SpO_2 decline in patients with complete apnea for up to 17 minutes [11]. The flow rate of 50 L/min was selected in this study based on the following three reasons: (1) literature research indicates that this flow rate can effectively prevent upper airway obstruction and collapse of soft tissues in the laryngopharyngeal cavity after anesthesia [2], and obese patients are highly prone to upper airway obstruction during surgery; (2)all patients included in this study are relatively young with good basic cardiopulmonary reserve function; (3) considering the potential risk of regurgitation and aspiration in obese patients, a moderate flow rate was selected to avoid the risk of gastric insufflation that may be associated with high flow rates.

The results of this study showed that during hysteroscopy with intravenous anesthesia in obese patients receiving oxygen via ordinary nasal cannula, respiratory depression and varying degrees of hypoxia are highly likely to occur, leading to a significant increase in the need for airway intervention support. With the use of THRIVE technology, only 6 patients in the observation group developed subclinical respiratory depression, 1 developed hypoxia, and no severe hypoxia occurred. After opening the airway, the oxygenation of patients improved rapidly, significantly reducing the need for airway-related support. This result is consistent with the meta-analysis results of Tan *et al.* [12], confirming the significant advantage of THRIVE technology in preventing complications related to respiratory depression during anesthesia. The possible reasons for the improvement of oxygenation by THRIVE technology are speculated as follows: (1) the heated and humidified high-concentration oxygen therapy system delivers high-flow oxygen far exceeding physiological requirements; (2) based on the principle of apneic oxygenation, changes in the patient's breathing pattern do not significantly affect the alveolar oxygen partial pressure level; (3) through low-level continuous positive airway pressure, it effectively maintains the stability of the upper airway anatomical structure after anesthesia and prevents airway collapse [13]. It is particularly noteworthy that no patient in the observation group required mask ventilation support, while the mask ventilation support rate in the control group was as high as 24.0%. This difference has important clinical significance, as on one hand, mask ventilation may increase the risk of gastric distension in patients, especially in obese patients, increasing the risk of regurgitation and aspiration; on the other hand, mask ventilation may temporarily interrupt the surgical procedure, affecting the smooth progress of the operation and reducing the utilization efficiency of the operating room.

Studies have shown that the use of THRIVE technology can reduce the incidence of postoperative hypoxemia and atelectasis in obese patients after general anesthesia [4]. During hysteroscopy with intravenous anesthesia, the deep sedative effect of propofol can reduce the muscle tone of the genioglossus muscle, causing upper airway obstruction at the levels of the soft palate, epiglottis, and tongue. In addition, in obese patients, their functional residual capacity is approximately 30% lower than that of normal individuals, so obese patients are highly prone to hypoxemia during non-intubated intravenous anesthesia [2]. Through the continuous positive airway pressure effect, THRIVE technology can partially compensate for the above physiological defects in obese patients during intravenous anesthesia, thereby reducing the occurrence of hypoxemia. The intraoperative arterial blood gas results showed that 5 minutes after anesthesia, due to the superimposed effect of respiratory depression caused by propofol and combined opioid drugs, the PaO_2 and SaO_2 in the control group were significantly lower than those in the observation group, while there was no statistically significant difference in pH value and $PaCO_2$ between the two groups. The results suggest that THRIVE technology mainly exerts its effect by improving oxygenation rather than affecting ventilation. Recent studies have explored the effect of THRIVE technology on ventilation in patients during hysteroscopy with intravenous anesthesia; through transcutaneous carbon dioxide monitoring of intraoperative carbon dioxide levels in the body, the results found that the peak value was (45±7) mmHg, which decreased to (44±5) mmHg at the end of the surgery, and no hypercapnia requiring manual intervention occurred throughout the procedure [14]. In this study, arterial blood gas analysis during and after surgery in both groups indicated that $PaCO_2$ was within the normal physiological range.

As a new ventilation and oxygen therapy method, the safety of THRIVE has always been a concern. Studies have shown that THRIVE can slightly increase airway pressure, which may have an adverse effect on hemodynamics, especially in obese patients [15]. The results of this study showed that compared with preoperative levels, the blood pressure and heart rate of both groups 5 minutes after anesthesia decreased to varying degrees, and the decrease in the observation group was more significant. It is speculated that this may be because high-flow technology can better improve hypoxia caused by respiratory depression during anesthesia in patients, as hypoxia can secondary lead to sympathetic nerve excitation. In addition, there was no statistically significant difference between the two groups in terms of anesthesia recovery time, anesthetic drug dosage, and complications, which initially indicates that THRIVE technology is generally safe and reliable. Domestic scholars have found through gastric ultrasound imaging evaluation that the application of THRIVE during the induction phase of general anesthesia in obese patients did not observe abnormal accumulation of gas in the stomach, indicating that this technology has no significant effect on intragastric pressure [16]. In addition, studies have shown that an increase in THRIVE gas flow rate will cause changes in the pressure gradient between the airway and the pharyngeal cavity: when the subject's mouth is closed, the pressure shows a non-linear upward trend with the increase of flow rate, while the pressure increase is significantly weakened when the mouth is open [17]. It is worth noting that even when the mouth is closed, the peak airway pressure remains stably below the safety threshold of 10 cm H_2O, indicating that this technology has controllable advantages in terms of respiratory mechanics [17]. These findings provide an important theoretical basis for the safe application of THRIVE in patients with sensitive airways or limited respiratory function.

The limitations of this study mainly include the small sample size and single-center design. Therefore, large-sample, multi-center studies are needed in the future for confirmation. In addition, there are certain limitations in $PaCO_2$ monitoring: restricted by clinical conditions, arterial blood gas analysis only before anesthesia induction, during surgery, and after awakening, failing to achieve continuous dynamic monitoring at each stage of the surgery, which makes it impossible to fully present the dynamic fluctuation characteristics of carbon dioxide levels and potential related influencing factors.

In summary, THRIVE technology can effectively improve the oxygenation status of obese patients during hysteroscopic surgery, reduce the incidence of hypoxia-related adverse events, and reduce the need for airway intervention. Future research can further explore the application effect of THRIVE technology in patients with different BMI grades, as well as its synergistic effect with different anesthesia regimens.

Conflict of Interest None

Reference

[1] Chinese Society of Cardiothoracic and Vascular Anesthesiology, Day Surgery Anesthesia Branch. Expert consensus on anesthesia management in hysteroscopy diagnosis and treatment[J]. J Clin Anesthesiol, 2020, 36(11): 1121-1125. **[In Chinese]**
[2] Arora L, Sharma S, Carillo JF. Obesity and anesthesia[J]. Curr Opin Anaesthesiol, 2024, 37(3): 299-307.
[3] Frat JP, Quenot JP, Badie J, et al. Effect of high-flow nasal Cannula Oxygen vs standard oxygen therapy on mortality in patients with respiratory failure due to COVID-19: the SOHO-COVID randomized clinical trial[J]. JAMA, 2022, 328(12): 1212-1222.
[4] Jaber S, De Jong A, Schaefer MS, et al. Preoxygenation with standard facemask combining apnoeic oxygenation using high flow nasal Cannula versuss standard facemask alone in patients with and without obesity: the OPTIMASK international study[J]. Ann Intensive Care, 2023, 13(1): 26.
[5] Ahmad I, El-Boghdadly K, Bhagrath R, et al. Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults[J]. Anaesthesia, 2020, 75(4): 509-528.
[6] Liu SX, Ye ZL, Mu XW, et al. High-flow nasal Cannula oxygen therapy versus non-invasive mechanical ventilation after extubation in AHF patients: a multicenter, prospective, randomized, controlled, clinical study[J]. Chin J Clin Res, 2022, 35(4): 462-466. **[In Chinese]**
[7] Zhou YD, Tian WQ, Ji FB, et al. Observation on the effect of nasal humidification and high flow ventilation in minimally invasive rotary resection of benign breast tumors under intravenous general anesthesia[J]. Shandong Med J, 2024, 64(8): 58-61. **[In Chinese]**
[8] Karlupia D, Garg K, Jain R, et al. Transnasal humidified rapid-insufflation ventilatory exchange versus conventional facemask breathing for preoxygenation during rapid sequence induction[J]. Cureus, 2023, 15(8): e43063.
[9] Girault C, Artaud-Macari E, Jolly G, et al. High-flow nasal oxygen therapy and hypercapnic acute respiratory failure[J]. Rev Mal Respir, 2024, 41(7): 498-507.
[10] Wang J, Tang N. Application of high flow nasal Cannula oxygen therapy in elderly patients with acute exacerbation of chronic obstructive pulmonary disease and type Ⅱ respiratory failure[J]. Chin J Clin Res, 2024, 37(2): 242-245. **[In Chinese]**
[11] Li YK, Yang JZ. Comparison of transnasal humidified rapid-insufflation ventilatory exchange and facemasks in preoxygenation: a systematic review and meta-analysis[J]. Biomed Res Int, 2022, 2022: 9858820.
[12] Tan JWY, Izhaak A, Abd Rahman R, et al. High-Flow Nasal Oxygen Therapy in Preventing Post-Exhumation Hypoxaemia and Postoperative Pulmonary Complications: A Systematic Review and Meta-Analysis[J]. Diagnostics (Basel). 2025;15(19):2449.
[13] Ananthapadmanabhan S, Gan YJ, Kudpaje A, et al. Use of THRIVE for apneic oxygenation in transoral laser microlaryngeal surgery: a scoping review[J].Laryngoscope, 2024, 134(10): 4203-4212.
[14] Frassanito L, Piersanti A, Vassalli F, et al. Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE) as unique technique for airway management during operative hysteroscopy under general anesthesia: a registered feasibility pilot cohort study[J]. Eur Rev Med Pharmacol Sci, 2022, 26(17): 6208-6214.
[15] Lyons C, Callaghan M. Uses and mechanisms of apnoeic oxygenation: a narrative review[J]. Anaesthesia, 2019, 74(4): 497-507.
[16] Jiang WQ, Shi L, Zhao Q, et al. Ultrasound assessment of gastric insufflation in obese patients receiving transnasal humidified rapid-insufflation ventilatory exchange during general anesthesia induction[J]. J South Med Univ, 2020, 40(11): 1543-1549. **[In Chinese]**
[17] Riva T, Meyer J, Theiler L, et al. Measurement of airway pressure during high-flow nasal therapy in apnoeic oxygenation: a randomised controlled crossover trial()[J]. Anaesthesia, 2021, 76(1): 27-35.

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·临床麻醉专题·论著·

经鼻湿化高流量通气在肥胖患者宫腔镜手术静脉麻醉中的应用

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摘要：目的　观察经鼻湿化高流量通气(THRIVE)在肥胖患者宫腔镜手术静脉麻醉期间的应用效果及不良反应发生情况。**方法**　选择2024年1月至12月南京中医药大学附属医院择期行宫腔镜手术的肥胖患者100例，按照随机数字表法随机分为观察组和对照组，每组50例。观察组采用THRIVE，对照组采用普通鼻导管吸氧。两组均采用静脉注射丙泊酚(1.5～2.5 mg/kg)复合静脉推注舒芬太尼(0.1 μg/kg)的静脉麻醉。比较两组麻醉前(T_0)、麻醉5 min(T_1)、苏醒5 min(T_2)时点的一般生命体征和动脉血气指标，记录两组缺氧相关不良事件发生率及处理情况、主要麻醉指标(苏醒时间、丙泊酚和舒芬太尼用量)、不良反应发生情况。**结果**　观察组T_1时点平均动脉压、心率均低于对照组，外周血氧饱和度高于对照组($P<0.05$)，其余时点两组生命体征差异无统计学意义($P>0.05$)。观察组的缺氧相关不良事件发生率均低于对照组(亚临床呼吸抑制：12.0% *vs* 44.0%，χ^2=12.689，$P<0.01$；缺氧：2.0% *vs* 18.0%，χ^2=7.111，P=0.008)；观察组的开放气道和面罩通气使用率亦低于对照组(12.0% *vs* 68.0%，χ^2=32.667，$P<0.01$；0 *vs* 12.0%，χ^2=12.636，$P<0.01$)。与对照组相比，观察组T_2时点动脉氧分压和动脉血氧饱和度更高($P<0.05$)，而pH值、动脉血二氧化碳分压两组比较差异无统计学意义($P>0.05$)；其余时点动脉血气各指标两组之间差异均无统计学意义($P>0.05$)。对照组和观察组患者不良反应总发生率比较差异无统计学意义[10.0%(5/50) *vs* 10.0%(5/50)，χ^2=0，P=1.000]。**结论**　肥胖患者宫腔镜手术静脉麻醉期间采用THRIVE，可以有效预防麻醉期间缺氧相关不良事件的发生，减少对气道支持的需求。

关键词： 经鼻湿化高流量通气；宫腔镜手术；肥胖；缺氧；丙泊酚；舒芬太尼；全身麻醉
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Application of transnasal humidified rapid-insufflation ventilatory exchange in intravenous anesthesia for obese patients undergoing hysteroscopic surgery

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Abstract: Objective　To observe the application effect of transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) during intravenous anesthesia for hysteroscopy in obese patients, as well as the incidence of adverse reactions. **Methods**　A total of 100 obese patients undergoing elective hysteroscopy at the Affiliated Hospital of Nanjing University of Chinese Medicine from January to December 2024 were selected. They were randomly divided into the observation group and the control group (n=50, each) using a random number table method. The observation group received THRIVE, while the control group was given conventional nasal cannula oxygen inhalation. Both groups were anesthetized with intravenous injection of propofol (1.5-2.5 mg/kg) combined with intravenous injection of sufentanil (0.1 μg/kg). General vital signs and arterial blood gas indicators were compared between the two groups at three time points: before anesthesia (T_0), 5 minutes after anesthesia (T_1), and 5 minutes after awakening (T_2). The incidence

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and management of hypoxia-related adverse events, main anesthetic indicators (awakening time, dosages of propofol and sufentanil), and occurrence of adverse reactions were recorded. **Results** At T_1, the mean arterial pressure and heart rate in the observation group were lower than those in the control group, while the saturation of peripheral oxygen was higher (P<0.05); there was no statistically significant difference in vital signs between the two groups at other time points (P>0.05). The incidence of hypoxia-related adverse events in the observation group was lower than that in the control group (subclinical respiratory depression: 12.0% *vs* 44.0%, χ^2=12.689, P<0.01; hypoxia: 2.0% *vs* 18.0%, χ^2=7.111, P=0.008). Additionally, the concurrent usage rate of open airway techniques and face masks in the observation group were also lower than those in the control group (12.0% *vs* 68.0%, χ^2=32.667, P<0.01; 0 *vs* 12.0%, χ^2=12.636, P<0.01). At T_2, the arterial partial pressure of oxygen and arterial oxygen saturation in the observation group were significantly higher; there was no statistically significant difference in pH value or arterial partial pressure of carbon dioxide between the two groups (P>0.05). No significant difference in arterial blood gas indicators was found between the two groups at other time points (P>0.05). There was no statistically significant difference in the total incidence of adverse reactions between the control group and the observation group [10.0%(5/50) *vs* 10.0%(5/50), χ^2=0, P=1.000]. **Conclusion** In obese patients undergoing hysteroscopic surgey, THRIVE can effectively prevent hypoxia-related adverse events during anesthesia and reduce the need for airway support.

Keywords: Transnasal humidified rapid-insufflation ventilatory exchange; Hysteroscopy; Obesity; Hypoxia; Propofol; Sufentanil; General anesthesia

宫腔镜手术是目前临床上应用较为广泛的妇科微创诊疗技术,其优势是可视化、出血量少、恢复快、住院时间短等[1]。目前国内专家共识推荐采用监测下的静脉麻醉(monitored anesthesia care,MAC)作为宫腔镜手术的标准麻醉管理方案[1]。临床常用的静脉麻醉药和阿片类药物可能导致呼吸抑制、术中低氧血症的发生率较高,这一现象在肥胖患者群体中尤为突出,其胸腹部脂肪堆积导致肺顺应性降低、功能残气量减少等生理改变,进一步增加了低氧血症的发生风险,严重时甚至需要转为气管插管全身麻醉[2]。经鼻湿化高流量通气(transnasal humidified rapid-insufflation ventilatory exchange,THRIVE)作为一种改良的高流量氧疗技术,无窒息氧合效应,引起了麻醉学界的广泛关注和研究[3-6]。前期临床研究观察发现THRIVE技术可以显著降低乳腺微创旋切术静脉麻醉期间缺氧相关不良事件的发生风险,进而降低气道支持需求,提高患者围手术期安全[7]。本研究旨在探讨THRIVE技术在肥胖患者宫腔镜手术静脉麻醉围手术期的应用价值,系统评估其安全性和有效性。

1 资料与方法

1.1 临床资料 本研究经南京中医药大学附属医院伦理委员会审批通过(伦理批号:2023NL-109-02),所有患者均签署知情同意书。研究时间为2024年1月至2024年12月,研究对象为在江苏省中医院接受择期宫腔镜手术的肥胖女性患者。纳入标准:(1)年龄18~60岁;(2)美国麻醉医师协会(American Society of Anesthesiologists, ASA)分级Ⅰ~Ⅱ级;(3)身体质量指数(body mass index, BMI)≥30 kg/m²。排除标准:(1)无法配合或耐受THRIVE技术;(2)有精神疾病史或长期使用镇静药物;(3)存在气道保护功能障碍或误吸高风险(如上消化道梗阻等);(4)对丙泊酚过敏;(5)重度阻塞性呼吸睡眠暂停综合征。按照随机数字表法将研究对象随机分为观察组和对照组,每组50例。观察组采用THRIVE,对照组采用普通鼻导管吸氧。两组年龄、BMI、ASA分级差异无统计学意义(P>0.05)。见表1。

表1 两组患者一般资料比较 (n=50, $\bar{x}\pm s$)

Tab.1 Comparison of general data between two groups (n=50, $\bar{x}\pm s$)

组别	年龄(岁)	BMI (kg/m²)	ASA分级(Ⅰ/Ⅱ,例)
对照组	32.2±4.5	35.3±2.2	32/18
观察组	31.3±4.2	34.8±2.0	30/20
t/χ^2值	1.034	1.189	0.217
P值	0.304	0.237	0.641

1.2 麻醉方法

1.2.1 术前准备 术前禁食8 h,禁饮2 h。入室后常规心电监护并建立静脉通路。术中氧疗方案,所有患者预吸氧5 min。对照组:双侧鼻导管吸氧,湿化瓶湿化,氧流量8 L/min;观察组:通过高流量湿化器(新西兰,费雪派克公司)给纯氧,氧流量8 L/min,温度37 ℃,患者意识消失后调整为50 L/min。两组麻醉均采用全凭静脉麻醉,静脉注射丙泊酚(江苏盈科生物

制药，国药准字H20223914）1.5～2.5 mg/kg复合静脉推注舒芬太尼（宜昌人福药业，国药准字H20205068）0.1 μg/kg，术中持续静脉泵注丙泊酚3~5 mg/（kg·h），且基于患者术中生命体征情况和手术反应适量追加麻醉药的用量，手术结束时停止丙泊酚泵注。

1.2.2　术中管理　亚临床呼吸抑制［外周血氧饱和度（saturation of peripheral oxygen，SpO_2）为90%~<93%］托下颌开放气道；缺氧（SpO_2 75%~<90%，持续时间<60 s）托下颌至SpO_2>95%；严重缺氧（SpO_2<75%或SpO_2 75%~<90%的持续时间≥60 s）立即停止手术，面罩加压给氧，必要时行气管插管机械通气。血流动力学管理：平均动脉压（mean arterial pressure，MAP）相比干预前下降20%，则静脉注射麻黄碱（成都倍特药业，国药准字H32021530）6 mg；心率<50次/min则静脉注射阿托品（津药和平制药，国药准字H12020385）

1.3　观察指标

1.3.1　一般生命体征指标　采集两组患者一般生命体征相关指标，主要包括麻醉前（T_0）、麻醉5 min（T_1）、苏醒5 min（T_2）时点的MAP、心率、SpO_2水平。

1.3.2　缺氧相关不良事件和处理措施的发生率　不良事件记录：亚临床呼吸抑制、缺氧、严重缺氧；处理措施记录：开放气道、面罩加压通气。

1.3.3　记录各时点动脉血气指标　记录患者T_0、T_1和T_2时的动脉血pH值、动脉血氧分压（arterial partial pressure of oxygen，PaO_2）、动脉血二氧化碳分压（arterial partial pressure of carbon dioxide，$PaCO_2$）、动脉血氧饱和度（arterial oxygen saturation，SaO_2）。

1.3.4　记录麻醉苏醒时间、麻醉药物用量　记录麻醉苏醒时间（手术结束至患者睁眼）、麻醉药物用量（丙泊酚和舒芬太尼用量）。

1.3.5　记录手术期间不良事件的发生情况　记录术后30 min内THRIVE相关并发症：鼻咽部不适、气压伤；术后恶心呕吐、反流误吸。

1.4　统计学方法　采用SPSS 25.0软件进行数据分析。正态分布计量资料以$\bar{x}\pm s$表示，组间比较采用t检验；多时点比较采用重复测量方差分析，两两比较采用LSD-t检验。计数资料以例（%）表示，组间比较采用χ^2检验。P<0.05为差异有统计学意义。

2　结　果

2.1　一般生命体征比较　观察组T_1时点MAP、心率均低于对照组，SpO_2高于对照组（P<0.05）；其余时点两组生命体征差异无统计学意义（P>0.05）。见表2。

2.2　两组患者不同时间点动脉血气指标比较　T_0和T_2时间点两组患者动脉血气各指标之间差异无统计学意义（P>0.05）；与对照组相比，观察组T_1时刻的PaO_2、SaO_2均更高，差异有统计学意义（P<0.05），而两组pH值、$PaCO_2$比较差异无统计学意义（P>0.05）。见表3。

2.3　两组缺氧相关不良事件及处理情况比较　观察组亚临床呼吸抑制、缺氧发生率低于对照组，差异有统计学意义（P<0.05）。在不良事件处理措施方面，观

表2　两组各时间点MAP、心率、SpO_2比较　（n=50，$\bar{x}\pm s$）

Tab.2　Comparison of MAP, heart rate, and SpO_2 between two groups at each time point　（n=50，$\bar{x}\pm s$）

组别	MAP（mmHg）			心率（次/min）			SpO_2（%）		
	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2
对照组	81.2±8.5	77.3±3.2	78.5±6.1	81.6±7.8	72.3±3.5	78.5±5.2	98.2±1.2	93.1±1.4	96.6±1.3
观察组	80.6±7.7	69.6±2.5[a]	77.3±5.7	78.4±7.6	66.5±2.8[a]	76.8±4.7	97.9±1.4	97.2±1.5[a]	97.4±1.2
$F_{时点}/F_{时间}/F_{交互}$值	38.720/20.730/10.680			99.000/30.480/3.437			120.400/98.510/73.230		
$P_{时点}/P_{时间}/P_{交互}$值	<0.001/<0.001/<0.001			<0.001/<0.001/0.034			<0.001/<0.001/<0.001		

注：与对照组同时间点比较，[a]P<0.05。

表3　两组患者不同时间点血气指标比较　（n=50，$\bar{x}\pm s$）

Tab.3　Comparison of blood gas indicators between two groups at different time point　（n=50，$\bar{x}\pm s$）

组别	pH			PaO_2（mmHg）			$PaCO_2$（mmHg）			SaO_2（%）		
	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2
对照组	7.4±0.1	7.3±0.1	7.3±0.1	89.4±6.3	78.3±5.4	86.2±5.6	40.6±3.2	45.5±3.3	44.5±3.3	97.3±1.6	94.2±1.6	96.2±1.7
观察组	7.4±0.0	7.4±0.1	7.4±0.0	87.4±5.6	182.0±31.3[a]	87.6±5.9	39.4±2.8	46.2±3.1	43.8±2.8	96.8±1.5	98.4±1.3[a]	96.5±1.6
$F_{时点}/F_{时间}/F_{交互}$值	4.790/0.299/1.198			314.500/462.300/470.800			94.690/1.255/2.536			7.001/53.090/62.940		
$P_{时点}/P_{时间}/P_{交互}$值	0.009/0.585/0.303			<0.001/<0.001/<0.001			<0.001/0.264/0.081			0.001/<0.001/<0.001		

注：与对照组同时点比较，[a]P<0.05。

察组患者需要开放气道、面罩通气发生率均更低，差异有统计学意义（$P<0.05$）。见表4。

2.4　两组麻醉苏醒时间、麻醉药物用量比较　两组患者在麻醉苏醒时间、丙泊酚和舒芬太尼用量组间比较差异无统计学意义（$P>0.05$）。见表5。

2.5　两组患者不良事件比较　对照组鼻咽部不适2例，恶心呕吐3例；观察组鼻咽部不适3例，恶心呕吐2例；两组均未发生气压伤和反流误吸。对照组和观察组患者不良反应总发生率比较差异无统计学意义［10.0%（5/50）*vs* 10.0%（5/50），$\chi^2=0$，$P=1.000$］。

表4　两组缺氧相关不良事件及处理情况比较　［n=50，例（%）］

Tab.4　Comparison of hypoxia-related adverse events and interventions between two groups　［n=50，case（%）］

组别	不良事件			处理措施	
	亚临床呼吸抑制	缺氧	严重缺氧	开放气道	面罩通气
对照组	22（44.0）	9（18.0）	3（6.0）	34（68.0）	12（24.0）
观察组	6（12.0）	1（2.0）	0	6（12.0）	0
χ^2值	12.689	7.111	1.370	32.667	12.636
P值	<0.001	0.008	0.227	<0.001	<0.001

表5　两组患者麻醉苏醒时间及麻醉药物用量比较　（n=50，$\bar{x}\pm s$）

Tab.5　Comparison of anesthesia emergence time and drug consumption between two groups　（n=50，$\bar{x}\pm s$）

组别	麻醉苏醒时间（min）	丙泊酚（mg）	舒芬太尼（μg）
对照组	8.8±1.6	215.5±27.5	8.5±1.6
观察组	9.8±2.2	225.6±31.2	8.6±1.8
t值	1.149	1.717	0.294
P值	0.253	0.089	0.770

3　讨　论

宫腔镜是用于子宫宫腔内检查和治疗的一种方式，具有创伤小、术后恢复快等优点[1]。由于术中需要扩张宫颈管，疼痛明显，而手术时间短，因此大部分都选择气管不插管的静脉麻醉[1]。由于麻醉期间镇静和镇痛麻醉药物的使用，显著增加了患者术中低氧血症的风险，肥胖患者由于体内氧储备少，气道更容易塌陷，极易发生低氧血症[2]，因而很有必要研究针对此类患者研究术中的最佳供氧方式，为手术的顺利进行提供良好保障。

THRIVE是高流量氧疗和窒息氧合交界的一项新技术，是一种可替代传统氧疗的窒息氧合技术[8]，在重症医学领域常被用来治疗重症肺炎合并呼吸衰竭的患者[9-10]。THRIVE技术供氧稳定性高，可精准控制温度，最高流速可达70 L/min；通过湍流、心源性震荡、哈尔登效应产生通气效应，从而让患者在窒息的状态肺泡也能够源源不断地获得氧气，部分排出体内的二氧化碳，理论上可以让患者在完全不通气的情况下17 min内不出现SpO_2下降[11]。本研究选择50 L/min流速，是基于以下3点原因：（1）文献研究提示，该流速可以有效预防麻醉后上呼吸道梗阻和咽喉腔软组织的塌陷[2]，而肥胖患者术中极易发生上呼吸道梗阻；（2）本研究纳入患者均较为年轻，基础心肺储备功能较好；（3）考虑到肥胖患者可能存在一定反流误吸的风险，为了避免高流量可能存在的胃进气的风险，因此选择中等流速。

本研究结果显示，在肥胖患者普通鼻导管吸氧宫腔镜静脉麻醉过程中，极易出现呼吸抑制和不同程度的缺氧，进而导致对气道干预支持的需求显著增加。而采用THRIVE技术，观察组只有6例患者出现亚临床呼吸抑制，1例出现缺氧，无严重缺氧，且开放气道之后，患者氧合迅速改善，显著减少了气道相关支持的需求，这一结果与Tan等[12]的meta分析结果一致，证实了THRIVE技术在预防麻醉期间呼吸抑制相关并发症方面具有显著优势。推测THRIVE技术改善患者氧合的可能原因：（1）通过加温湿化的高浓度氧疗系统输出远超生理需求的高流量氧气；（2）基于窒息氧合原理，患者呼吸模式变化不会显著影响肺泡氧分压水平；（3）通过低水平持续气道正压，有效维持麻醉后上气道解剖结构的稳定性，防止气道塌陷[13]。特别值得注意的是，观察组无患者需要面罩通气支持，而对照组的面罩通气支持率高达24.0%，这一差异具有重要的临床意义，因为一方面面罩通气可能增加患者胃胀气风险，特别是在肥胖患者中，增加了反流误吸的风险；另一方面可能会因为面罩通气暂时中断手术操作，影响手术的顺利进行，降低手术间的使用效率。

研究表明，采用THRIVE技术可以降低肥胖患者全身麻醉术后低氧血症、降低肺不张的发生率[4]。在宫腔镜静脉麻醉过程中，由于丙泊酚的深度镇静作用，可以降低颏舌肌的肌张力，在软腭、会厌和舌水平造成上呼吸道梗阻，此外肥胖患者中，其功能残气量较正常人降低约30%，因此肥胖患者采用非插管静脉麻醉期间，极易发生低氧血症[2]。THRIVE技术通过持续的气道正压作用，能够部分代偿静脉麻醉期间的肥胖患者的上述生理缺陷，从而减少患者低氧血症的发生。术中的动脉血气结果提示，麻醉后5 min，由于丙泊酚和复合的阿片药物造成的呼吸抑制叠加作

用，对照组PaO_2和SaO_2显著低于观察组，而两组间pH值和$PaCO_2$差异无统计学意义。结果提示，THRIVE技术主要通过改善氧合而非影响通气来发挥作用。近期有研究探讨了THRIVE技术对宫腔镜静脉麻醉期间患者通气的影响；通过经皮二氧化碳监测术中体内二氧化碳水平，结果发现其峰值为(45±7)mmHg，术毕时降至(44±5)mmHg，全程未出现需人工干预的高碳酸血症[14]。本研究两组患者术中、术毕动脉血气分析均提示$PaCO_2$均处于正常生理范围。

THRIVE作为一项新的通气氧疗方式，其安全性一直是备受关心的问题。研究表明，THRIVE可以轻度升高气道压，对血流动力学可能造成不利影响，特别是对肥胖患者[15]。本研究结果表明，同术前相比，两者麻醉后5 min的血压、心率较术前均有不同程度的下降，而观察组下降的幅度更大；推测可能是高流量技术可以更好地改善患者麻醉中的呼吸抑制导致的缺氧，因为缺氧可以继发性的导致交感神经的兴奋。此外，两组患者在麻醉苏醒时间和麻醉药物用量及并发症方面，差异无统计学意义，这初步表明THRIVE技术总体安全可靠。国内有学者通过胃超声影像学评估发现，在肥胖患者全身麻醉诱导阶段应用THRIVE，未观察到胃内气体异常蓄积现象，表明该技术对胃内压无显著影响[16]。此外，也有研究表明，THRIVE气体流速的提升会引发气道与咽腔压力梯度变化：当受试者闭口状态下，压力随流速增加呈现非线性上升趋势，而张口时压力增幅显著减弱[17]。值得注意的是，即使处于闭口状态，气道压力峰值仍稳定低于10 cmH_2O的安全阈值，提示该技术在呼吸力学层面具有可控性优势[17]。这些发现为THRIVE在气道敏感或呼吸功能受限患者中的安全应用提供了重要理论依据。

本研究的局限主要是样本少，且为单中心的，因而以后需要进行大样本、多中心的研究来证实；此外在$PaCO_2$监测方面存在一定局限性：受临床制约，动脉血气分析仅覆盖麻醉诱导前、术中、苏醒后3个时间节点，未能实现术中各阶段的连续动态监测，致使无法完整呈现二氧化碳水平的动态波动特征及潜在相关影响因素。

综上所述，THRIVE技术能够有效改善肥胖患者宫腔镜手术期间的氧合状态，降低缺氧相关不良事件的发生率，减少气道干预需求。未来研究可进一步探讨THRIVE技术在不同BMI分级患者中的应用效果，以及其与不同麻醉方案的协同作用。

利益冲突　无

参考文献

[1] 中国心胸血管麻醉学会日间手术麻醉分会.宫腔镜诊疗麻醉管理的专家共识[J].临床麻醉学杂志，2020，36(11)：1121-1125.

[2] Arora L，Sharma S，Carillo JF. Obesity and anesthesia[J]. Curr Opin Anaesthesiol，2024，37(3)：299-307.

[3] Frat JP，Quenot JP，Badie J，et al. Effect of high-flow nasal cannula oxygen *vs* standard oxygen therapy on mortality in patients with respiratory failure due to COVID-19：the SOHO-COVID randomized clinical trial[J]. JAMA，2022，328(12)：1212-1222.

[4] Jaber S，De Jong A，Schaefer MS，et al. Preoxygenation with standard facemask combining apnoeic oxygenation using high flow nasal cannula versuss standard facemask alone in patients with and without obesity：the OPTIMASK international study[J]. Ann Intensive Care，2023，13(1)：26.

[5] Ahmad I，El-Boghdadly K，Bhagrath R，et al. Difficult Airway Society guidelines for awake tracheal intubation（ATI）in adults[J]. Anaesthesia，2020，75(4)：509-528.

[6] 刘尚香，叶正龙，穆心苇，等.急性心力衰竭有创机械通气拔管后经鼻高流量氧疗和无创机械通气的多中心前瞻性随机对照研究[J].中国临床研究，2022，35(4)：462-466.

[7] 周玉弟，田伟千，季方兵，等.经鼻湿化高流量通气在静脉全麻乳腺良性肿瘤微创旋切术中的应用效果观察[J].山东医药，2024，64(8)：58-61.

[8] Karlupia D，Garg K，Jain R，et al. Transnasal humidified rapid-insufflation ventilatory exchange versus conventional facemask breathing for preoxygenation during rapid sequence induction[J]. Cureus，2023，15(8)：e43063.

[9] Girault C，Artaud-Macari E，Jolly G，et al. High-flow nasal oxygen therapy and hypercapnic acute respiratory failure[J]. Rev Mal Respir，2024，41(7)：498-507.

[10] 王晶，唐娜.经鼻高流量氧疗在老年慢性阻塞性肺疾病急性加重期伴Ⅱ型呼吸衰竭患者中的应用[J].中国临床研究，2024，37(2)：242-245.

[11] Li YK，Yang JZ. Comparison of transnasal humidified rapid-insufflation ventilatory exchange and facemasks in preoxygenation：a systematic review and meta-analysis[J]. Biomed Res Int，2022，2022：9858820.

[12] Tan JWY，Izhaak A，Abd Rahman R，et al. High-flow nasal oxygen therapy in preventing post-exhumation hypoxaemia and post-operative pulmonary complications: a systematic review and meta-analysis[J]. Diagnostics (Basel)，2025，15(19)：2449.

[13] Ananthapadmanabhan S，Gan YJ，Kudpaje A，et al. Use of THRIVE for apneic oxygenation in transoral laser microlaryngeal surgery：a scoping review[J]. Laryngoscope，2024，134(10)：4203-4212.

[14] Frassanito L，Piersanti A，Vassalli F，et al. Transnasal humidified rapid-insufflation ventilatory exchange（THRIVE）as unique technique for airway management during operative hysteroscopy under general anesthesia：a registered feasibility pilot cohort study[J]. Eur Rev Med Pharmacol Sci，2022，26(17)：6208-6214.

[15] Lyons C，Callaghan M. Uses and mechanisms of apnoeic oxygenation: a narrative review[J]. Anaesthesia，2019，74(4)：497-507.

[16] 蒋卫清，石莉，赵倩，等.快充式经鼻湿化高流量通气对肥胖患者全麻诱导期胃进气的影响：基于超声评估的90例前瞻性临床试验[J].南方医科大学学报，2020，40(11)：1543-1549.

[17] Riva T，Meyer J，Theiler L，et al. Measurement of airway pressure during high-flow nasal therapy in apnoeic oxygenation：a randomised controlled crossover trial[J]. Anaesthesia，2021，76(1)：27-35.

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