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ORIGINAL RESEARCH

Clinical Application of Ultrasound-Guided Internal Branch of Superior Laryngeal Nerve Block in Patients with Severe COPD Undergoing Awake Fibreoptic Nasotracheal Intubation: A Randomized Controlled Clinical Trial

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Purpose: The aim was to investigate the time for intubation, adverse events and the comfort score of ultrasound-guided internal branch of superior laryngeal nerve block in patients with severe chronic obstructive pulmonary disorder (COPD) undergoing awake fibreoptic nasotracheal intubation.

Methods: Sixty patients with COPD who needed awake fibreoptic nasotracheal intubation were randomly and evenly divided into the ultrasound-guided internal branch of the superior laryngeal nerve block group (group S) and the control group (group C). All patients received procedural sedation with dexmedetomidine and adequate topical anaesthesia of the upper respiratory tract. Then, bilateral block was performed (with 2 mL of 2% lidocaine or the same volume of saline) followed by fibreoptic nasotracheal intubation. The primary outcomes were time for intubation, adverse reactions and comfort score. The secondary outcomes were haemodynamic changes and serum norepinephrine (NE) and adrenaline (AD) concentrations immediately before intubation (T0); immediately after intubation to the laryngopharynx (T1); and immediately (T2), 5 min (T3) and 10 min (T4) after intubation between the groups.

Results: Compared with group C, the time for intubation, the incidence of adverse reactions and the comfort score in group S were significantly lower ($P<0.01$). Compared with T0, the mean arterial pressure (MAP), heart rate (HR), NE and AD were significantly higher at T1 - T4 in group C ($P<0.05$), but were not obviously higher at T1 - T4 in group S ($P>0.05$). MAP, HR, NE and AD at T1–T4 were significantly lower in group S than in group C ($P<0.05$).

Conclusion: Ultrasound-guided internal branch of the superior laryngeal nerve block can effectively shorten the time for intubation, reduce the incidence of adverse reactions, improve comfort score, maintain considerable haemodynamic stability and inhibit stress response in patients with severe COPD undergoing awake fibreoptic nasotracheal intubation.

Keywords: COPD, awake fibreoptic nasotracheal intubation, the time for intubation, stress response, ultrasound-guided the internal branch of the superior laryngeal nerve block

Introduction

Chronic obstructive pulmonary disease (COPD) is a destructive disease characterised by chronic airflow limitation that cannot be completely reversed and is usually progressive. It is a main cause of morbidity and mortality worldwide and its prevalence is increasing.[1–3] Patients with COPD need invasive mechanical ventilation when they progress to respiratory failure.[4,5] In routine clinical practice, sedatives, analgesics and muscle relaxants are used to facilitate direct laryngoscopy intubation. However, this technique may lead to severe haemodynamic instability and lung injury caused by subsequent mechanical ventilation.[6–8] Compared with oral approach, awake nasotracheal intubation was usually easier with a higher

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success rate.[9–11] Hawkyard et al[12] showed that awake fibreoptic nasal intubation reduced the pressor response to endotracheal intubation in normotensive adults. Moreover, Putensen et al[13] reported that the results suggested that spontaneous breathing during ventilator support did not have to be suppressed even in patients with severe pulmonary dysfunction. Xia et al[14] showed that preserving spontaneous breathing could not only improve ventilatory function but also attenuate selected markers of ventilator-induced lung injury in mechanically ventilated healthy lung. Nasotracheal intubation guided by a fibreoptic bronchoscope (FB) is the most commonly used method with more advantages.[11,15] However, most patients with COPD are older and often have cardio-cerebrovascular and/or other basic diseases. Even with gentle operation and perfect surface anaesthesia, intubation still causes a strong response, in addition to a high incidence of myocardial ischaemia, cardio-cerebrovascular accidents and other complications. Furthermore, intubation can even endanger the patient's life.[16–19]

Traditionally, surface anaesthesia, sedatives and analgesics are used to establish intubation conditions, but a lower dose can cause a strong stress response and an excessive dose can result in respiratory depression or other risks of intubation. Therefore, how to improve patient safety is a clinical problem that needs to be solved urgently.[20–22] Previous studies have shown that sufficient airway anaesthesia is essential to suppress gag, swallow and cough reflexes prior to awake endotracheal intubation, and with the development of ultrasound visualisation technology, ultrasound-guided internal branch of the superior laryngeal nerve block (UGISLNB) has many benefits for awake nasotracheal intubation guided by an FB.[15,23–27] However, the clinical application of UGISLNB in patients with COPD who develop severe respiratory failure and require fibreoptic nasotracheal intubation has not been studied. Hence, the purpose of this randomised controlled clinical trial is to assess the time for intubation, adverse events, comfort score and stress response to UGISLNB in patients with severe COPD undergoing awake fibreoptic nasotracheal intubation; to verify its safety and efficacy; and to provide a clinical reference.

Patients and Methods

Study Design

This study was a randomised, double-blind, controlled, single-centre clinical trial. The study was approved by the Ethics Committee of The Second Hospital of Shandong University (No. KYLL-2020LW-057). The trial was registered at the Chinese Clinical Trial Registry (ChiCTR2000040185) prior to patient enrolment. The study was conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants (and, if necessary, their guardians). A CONSORT checklist was used for patient enrolment and allocation (Figure 1).

Participants

Participants were eligible for awake fibreoptic nasotracheal intubation if patients with COPD whose condition could not be relieved through a non-invasive ventilator (NIPPV) or who could not tolerate NIPPV and required invasive mechanical ventilation, according to Guidelines for COPD, from 1 December 2020 to 31 July 2021. The inclusion criteria were as follows: aged 35–85 years; American Society of Anaesthesiologists (ASA) score III–IV; and a signed informed consent form. The exclusion criteria were as follows: patients who refused to give consent; uncooperative patients; severe hypertension or heart disease (eg BP≥160 mmHg and/or ≥110 mmHg and HR≥100 bpm, New York Heart Association [NYHA] Class ≥ II, ischaemic heart disease, atrial fibrillation); severe hepatorenal insufficiency (HILD grade <10 and creatinine ≥500μmol/L); nasopharyngeal diseases or lower respiratory tract hypersensitivity diseases; laryngeal oedema, acute/chronic pharyngitis or acute airway inflammation (eg acute tracheobronchitis); asthma attack; abnormal coagulation; contraindications for nasotracheal intubation; contraindications for regional block (eg bleeding diathesis, local infection and local anaesthetic toxicity); recent use of sedatives, analgesics, β-blockers or β-agonists (within 2 weeks); allergy or contraindication to the drugs used in this study; anatomic abnormalities in the head, neck, face, nose, mouth or airway; pregnant or lactating women; body mass index (BMI) >30 kg/m^2; fasting time <6h; difficult airway evaluated before operation; change in the intubation method; serious complications or other accidents; any reason not to cooperate with research and/or any factor influenced the results or the researchers thought that should be excluded (eg the patient's respiratory or circulatory system deteriorated and they required immediate emergency treatment).

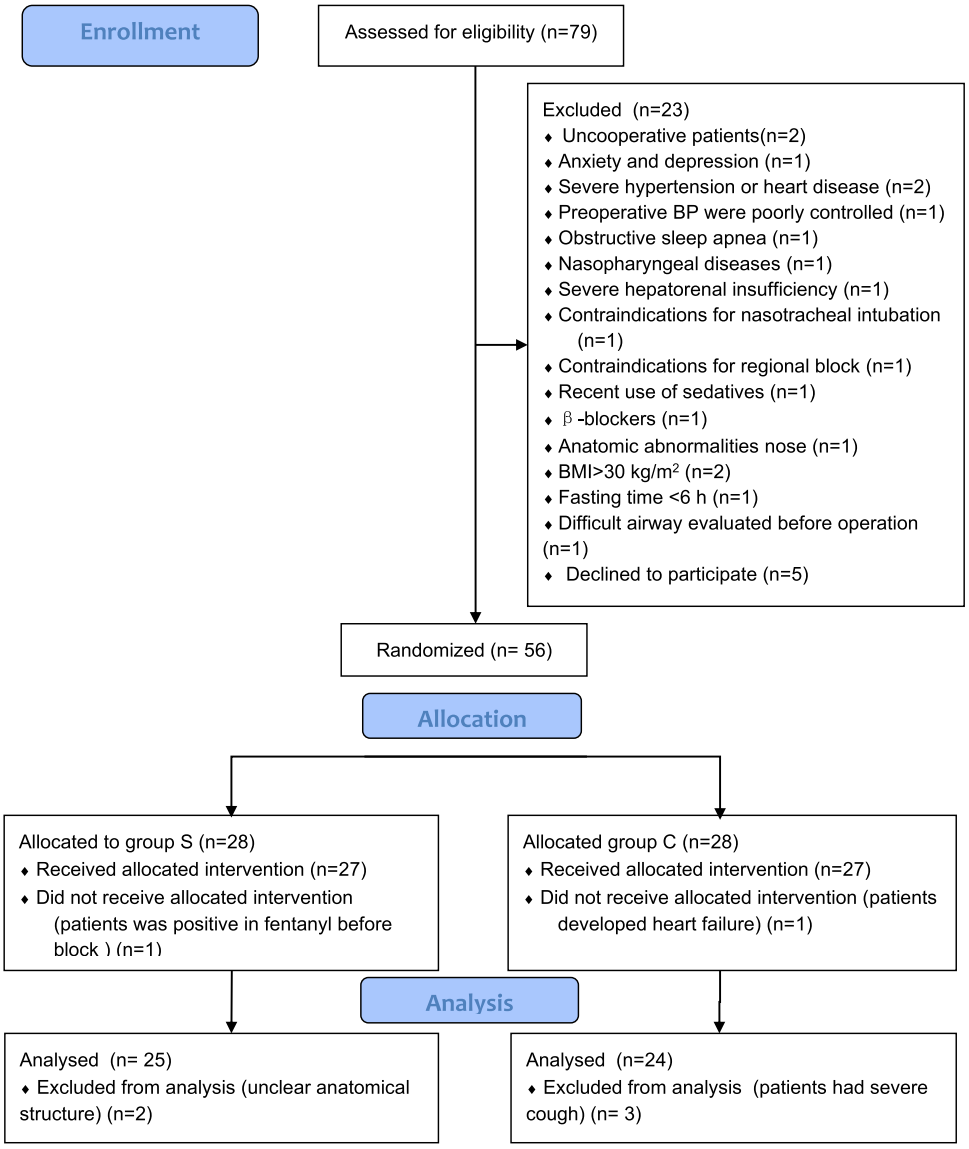


Figure 1 Flow diagram of the study.

Interventions

The patients were randomly divided into two groups in a blinded fashion (a sealed opaque envelope) by the administrator who did not take part in the treatment: the UGISLNB group (group S, n=30) and the control group (group C, n=30).

All patients were administered intravenous (iv) raceanisodamine 0.3 mg for inhibition of gland secretion, iv fentanyl 0.5 μg/kg for analgesia, iv dexamethasone 0.2 mg/kg for oedema prophylaxis and iv ondansetron 8 mg to prevent vomiting before the operation. They also received education (eg on the awake fibreoptic intubation procedure) to relieve their anxiety. Electrocardiogram (ECG), mean arterial pressure (MAP), HR, saturation of peripheral oxygen (SPO_2) and end-tidal carbon dioxide ($ETCO_2$) monitoring were applied throughout the procedure. Furthermore, patients received high-flow oxygen inhalation via a nasal cannula (if necessary, moving to the non-intubated nostril). Both groups received dexmedetomidine (DEX) at a loading dose of 0.5–1 μg/kg over 15 min followed by a continuous infusion of 0.25 μg/kg/h. The surface of the FB and the endotracheal tube were coated with liquid paraffin oil. The more unobstructed side nasal cavity was chosen, and then 1% ephedrine was applied to contract the nasal mucosa and 3 mL of 2% lidocaine mucilage was smeared over the nasal cavity and the posterior nostril to reduce damage. Then, the hard palate, soft palate, tongue, root of the tongue, posterior pharyngeal wall, epiglottis and glottic cleft mucosa were sprayed with a total of 5 mL of 1%

tetracaine. Besides, the cricothyroid membrane was injected with 3 mL of 2% lidocaine to anaesthetise the tracheal surface. Finally, UGISLNB was performed. The patients were placed in supine position, with the neck extended, and a high-frequency (11 MHz) linear ultrasound probe (Vivid S70N, GE Healthcare) was used. Using an aseptic technique, the transducer was placed over submandibular area with parasagittal orientation. The greater horn of hyoid bone and thyroid cartilage were identified as hyperechoic structures on ultrasonography. The thyrohyoid muscle and the thyrohyoid membrane were between the two structures. The superior laryngeal nerve (SLN) area was defined as bounded by the hyoid bone cephalad, the thyroid cartilage caudally, the thyrohyoid muscle anteriorly and the thyrohyoid membrane and the pre-epiglottic space posteriorly.[28] Using an out-of-plane approach, 2 mL of 2% lidocaine in group S or normal saline in group C was injected using a 24G needle between the horn of the hyoid bone and the thyroid cartilage just above the thyrohyoid membrane, followed by local compression and observation for 5 min. Attention was paid to needle withdrawal after drug injection. The procedure was then performed on the opposite side (Figure 2).

Approximately 5 min after blockade, the tracheal tube (the size 6.5–7.0 mm diameter in men, 7.0–6.5 mm diameter in women by sex and nostril size) was gently advanced into the pharyngeal cavity through the prepared nasal cavity. The FB was inserted through the endotracheal tube gradually until the glottis could be seen. When the glottis was open, the FB was placed close to the tracheal carina, and then the tracheal tube was slowly inserted into the appropriate position. Finally, the FB was pulled out. The success of the tracheal intubation was confirmed by the $ETCO_2$ waveform. If MAP was more than or less than 30% of baseline values, thenurapidil 12.5 mg or norepinephrine 50 μg, respectively, was injected intravenously. If tachycardia (HR>100bpm) or bradycardia (HR<60bpm) occurred, then esmolol 20 mg or atropine 0.5 mg, respectively, was injected intravenously and repeated, if needed. Patients were instructed to take a deep breath, and while holding their breath, there should be respiratory depression or a sharp fall in SPO_2 in a short time. If the results were not satisfactory, they were switched to high-flow oxygen through the face mask immediately. The procedure was stopped if the patient had a severe cough or strong body movements. If necessary, sedatives, analgesics and muscle relaxants were added to complete this operation; in these cases, the patient was withdrawn from the study. If the patient's anatomical structure was abnormal or unclear, the block could not be performed, which was considered as UGISLNB failure and discontinued intervention. If there were any signs of local anaesthetic systemic toxicity (eg oral numbness, dizziness or light-headedness, drowsiness or disorientation, visual or auditory disturbances, muscle twitching, seizures,

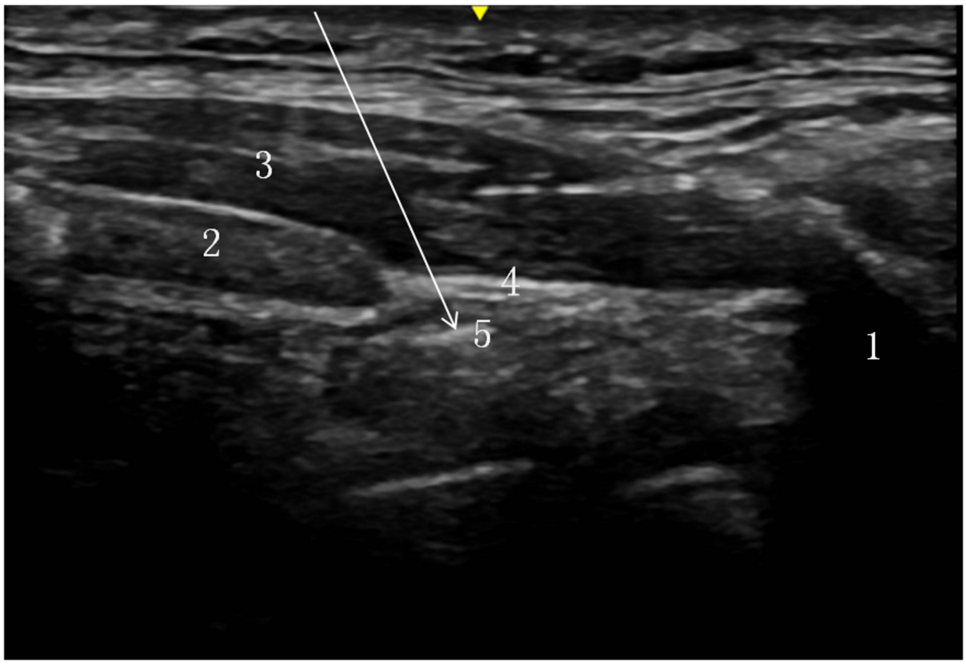


Figure 2 The view of ultrasound-guided superior laryngeal nerve block. Hyoid bone, 1; thyroid cartilage, 2; thyrohyoid muscle, 3; thyrohyoid membrane, 4; superior laryngeal nerve, 5; the arrow denotes the puncture path of the needle.

loss of consciousness, hypertension, tachycardia, bradycardia, cardiac arrhythmias, asystole) were observed, the patient was withdrawn from the study. All treatment decisions were made by an experienced anaesthesiologist and pulmonary physician. Both consultant anaesthetists were present during all procedures. One was responsible for performing local anaesthesia and the awake nasal fibreoptic intubation, and the other administered the study drugs. A doctor collected anaesthetic data and perioperative records, and neither researchers nor patients knew of group assignments during the study.

Data Collection

The primary outcomes were the time for intubation (from the beginning of FB insertion through the nostril to successful endotracheal tube placement), adverse reactions, including nausea and vomiting (the nausea and vomiting occurred during and after intubation), cough, body movement (serious body reaction affecting the procedure), hypertension (BP>160/110mmHg), hypotension (BP<90/60mmHg), tachycardia (100>bpm) and bradycardia (HR<60 bpm) and the comfort score (1 = excellent, indicating a calm patient; 2 = good, indicating a comfortable patient; 3 = moderate, there is a need to pacify the patient; 4 = poor, indicating an uncomfortable patient; 5 = agitated patient).[29] The secondary outcomes were hemodynamic changes (MAP and HR) and serum norepinephrine (NE) and adrenaline (AD) concentrations immediately before intubation (T0), immediately after intubation to laryngopharynx (T1); and immediately (T2), 5 min (T3) and 10 min (T4) after intubation. Peripheral venous blood samples (8 mL) were collected in EDTA anticoagulation test tube. They were centrifuged at 3000 rpm for 10 min at 4°C (centrifugal radius of 10 cm). The plasma was collected and stored at-80°C until analysis. The plasma AD and NE concentrations were determined by high-performance liquid chromatography (HPLC) (Agilent 1260 HPLC system, Agilent Technologies) with the electrochemical method.

Sample Size Calculation

The sample size was estimated using PASS 11.0 (NCSS-PASS 11, USA). According to the results of a preparatory experiment, the time for intubation, representing a major endpoint after intubation, was 83.7±13.5 in group S and 101.1 ±16.2 in group C, and the comfort score, representing another major endpoint after intubation, was 3.3±0.9 in group S and 4.1±0.5 in group C. The sample size was estimated separately based on the time for intubation and comfort score using a two-sample *t*-test with a significance level of 5% and β power of 0.10. The size of each group was estimated to be 16 cases based on the time for intubation and 18 cases based on the comfort score. We chose the maximum sample size (18), considering a 20% dropout rate, and then the sample size was N1=N2=18÷0.8=23 cases, 49 patients (25 cases in group S and 24 cases in group C) would be sufficient in this trial.

Statistical Analysis

The continuous variables were assessed for normality using the normal quantile–quantile plot, which showed that they obeyed a normal distribution. The AD and NE concentrations, HR and MAP were analysed by analysis of variance (ANOVA) for intra-group comparisons and one-way ANOVA for inter-group comparisons. The time for intubation and the comfort score were compared using independent sample *t*-tests. The incidence of postoperative adverse events was compared by Fisher's exact test. Patient characteristics were analysed by independent sample *t*-test or Fisher's exact test. $P<0.05$ was considered statistically significant. Data are expressed as mean ± standard deviation (SD) or the number (proportion) as appropriate. All the analyses were carried out with SPSS 23.0 version (IBM Corp., Armonk, NY, USA).

Results

A total of 79 patients were enrolled in the study. Twenty-three patients were excluded because they met the exclusion criteria (n=18) or did not provide consent (n=5). One patient developed heart failure and three patients had severe cough and thus had to be changed to method of intubation in group C. In addition, in group S one case was positive for fentanyl before the block and two cases had an unclear anatomical structure and the block could not be completed. These patients were excluded. UGSLNB and intubation of the other patients were completed on the first attempt. Finally, 56 patients were included in the study.

Table 1 Patient and Procedure Characteristics in the Two Groups

Characteristic	Group S (n = 25)	Group C (n = 24)	*P*-value
Sex (n, male/female)	20/5	18/6	0.68*
Age (years)	69.5 ± 9.3	67.5 ± 10.9	0.50#
ASA classification (n, III/IV)	7/18	5/19	0.56*
Weight (kg)	57.6 ± 9.7	56.2 ± 7.7	0.57#
BMI (kg/cm^2)	21.3 ± 2.1	22.2 ± 2.6	0.19#
PH	7.21 ± 0.05	7.19 ± 0.05	0.32#
PaO_2/FiO_2	174 ± 23	177 ± 18	0.57#
$PaCO_2$ (mmHg)	81 ± 7.9	78 ± 6.8	0.20#
Dexmedetomidine dose (μg)	34.5 ± 6.5	33.5 ± 4.9	0.57#
Fentanyl dose (μg)	28.8 ± 4.8	28.1 ± 3.8	0.57#

Notes: Data are presented as mean ± standard deviation or the number of patients. group S received ultrasound-guided superior laryngeal nerve block; group C was the control group. *Fisher's exact test for statistical analysis. #Independent samples *t*-test for statistical analysis.

Abbreviations: ASA, American Society of Anaesthesiologists; BMI, body mass index; FiO_2, fraction of inspiration O_2; $PaCO_2$, partial pressure of arterial carbon dioxide; PaO_2, partial pressure of arterial oxygen.

The patient characteristics at baseline were well balanced between the groups (Table 1). Compared with group C, the time for intubation, the incidence of adverse reactions and the comfort score in group S were significantly lower ($P<0.01$) (Figure 3 and Table 2). Compared with T0, MAP, HR, NE and AD were significantly higher at each time point (T1–T4) in group C ($P<0.05$), but they were not significantly higher in group S ($P>0.05$). MAP, HR, NE and AD in group S at each time point (T1–T4) were significantly lower than those in group C ($P<0.05$). There was no significant difference in MAP, HR, NE and AD between the groups at T0 (baseline) ($P>0.05$) (Figures 4 and 5).

Discussion

In this study, we have shown that the successful application of UGISLNB could effectively shorten the time for intubation, reduce incidence of adverse reactions, improve the comfort score, maintain considerable haemodynamic stability and inhibit the stress response of patients with severe COPD undergoing awake fibreoptic nasotracheal intubation.

It is well known that the keys to successful intubation are to provide adequate anaesthesia to ensure patient comfort as well as adequate sedation, to control secretions and to minimise adverse reactions. Only when the above factors are met

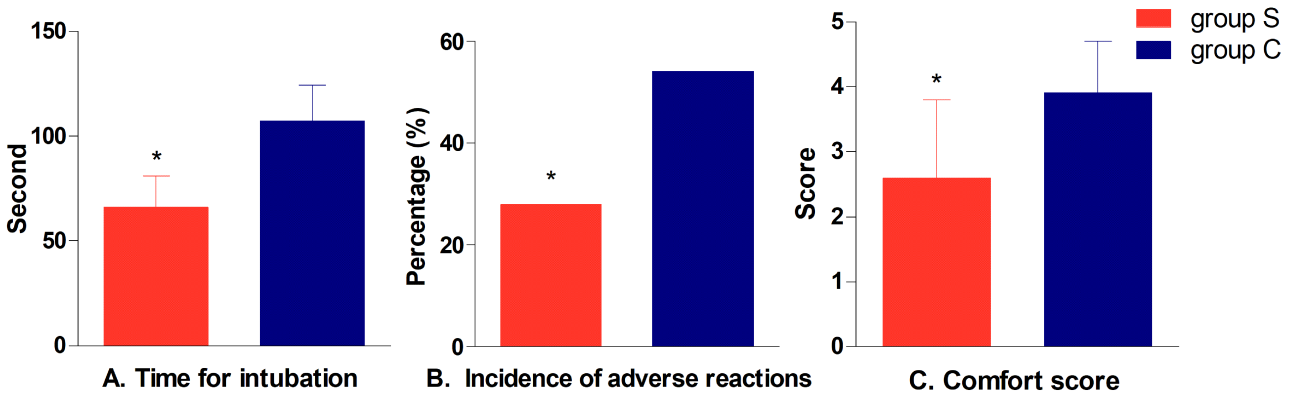


Figure 3 Comparison of the time for intubation (**A**), the incidence of adverse reactions (**B**) and the comfort score (**C**). (**A** and **C**) The data are expressed as the mean ± standard deviation compared with group C. The data were compared with an independent sample *t*-test; *$P<0.01$. (**B**) The data are expressed as the percentage, compared with group C. Data were compared with Fisher's exact test; *$P<0.01$. Group S received ultrasound-guided superior laryngeal nerve block; group C was the control group.

Table 2 Time for Intubation, Comfort Score and Incidence of Adverse Reactions in the Two Groups

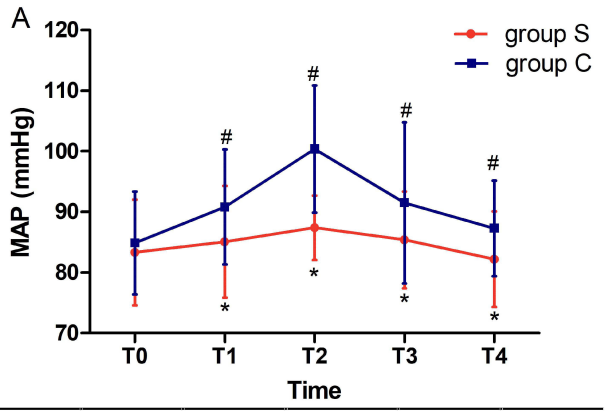
Characteristic		Group S (n = 25)	Group C (n = 24)	*P*-value
Time for intubation (sec)		66.2±14.8	107.3±17.0	<0.01[#]
Comfort score		2.6±1.2	3.9±0.8	<0.01[#]
Adverse reactions	NVDP(n)	3	5	
	Cough (n)	2	3	
	Body movement (n)	1	2	
	Hypertension (n)	1	2	
	Hypotension (n)	0	0	
	Tachycardia (n)	0	1	
	Bradycardia (n)	0	0	
	Total (n)	7	13	
	Incidence(%)	28.0	54.2	<0.01*

Notes: The data are presented as the number or percentage. group S received ultrasound-guided superior laryngeal nerve block; group C was the control group. [#]Independent samples *t*-test for statistical analysis. *Fisher's exact test for statistical analysis.
Abbreviation: NVDP, Nausea or vomiting during procedure.

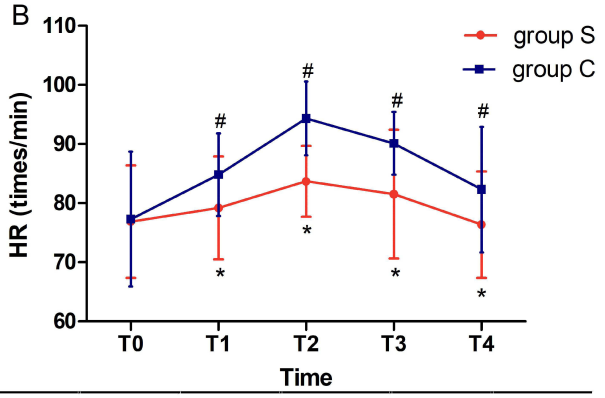
can the time for intubation be controlled and kept to a minimum. In the present study, compared with group C, the time for intubation; the incidence of adverse reactions and the comfort score were lower in group S ($P<0.01$). There are several possible reasons: the block effect was so exact that the stress response was reduced, or the haemodynamic fluctuation was small and the adverse reaction was greatly decreased, resulting in active cooperation from the patients. As a result, there was an increase in the comfort score and a marked reduction in the intubation time. Besides, relaxation of laryngeal muscles and reducing vocal cord movement are also the key to awake intubation; these changes allow the catheter to pass through the airway more smoothly, and thus the time for intubation is shorter. The findings are similar to those reported by Gupta et al.[25] In that study, comfort was better in the nerve block group compared with the nebulisation group, which was deduced from the patient assessment of procedure recall. Uday et al[26] also showed that the quality of airway anaesthesia was better in UGISLNB group, including a shorter intubation duration and better patient tolerance. Studies have shown that combination of SLN block with topical airway anaesthesia produces better patient comfort.[30] Zhou et al[31] reported that UGISLNB can reduce the coughing score and decrease the incidence of hypoxemia, without increasing adverse events. Moreover, hypotension and bradycardia have also been associated with excessive manipulation of the larynx causing vasovagal reaction.[32] These phenomena did not occur in our trial, possibly due to good effects of UGISLNB.

Endotracheal intubation is related to elevated BP, HR and catecholamines due to intense sympathetic discharge caused by stimulation of the upper respiratory tract. Although the transient stress response has little effect on young patients, haemodynamic changes may be fatal to more vulnerable patients. Therefore, it is important in older adult patients to avoid a significant stress response during tracheal intubation.[18,33,34] In general, when the patient is awake, the glottic reflex is active, meaning that the intubation success rate is lower. The endotracheal tube stimulates the throat, glottis and tracheal mucosa, which may cause a strong stress response. Then, sympathetic-adrenal medulla system is activated, resulting in high BP and increased HR.[35,36]

Previous studies have shown that endotracheal intubation can induce a stress response and excite the sympathetic nervous system. In addition, the catecholamine concentration in the body increases sharply within a few seconds, and consequently the change in the plasma catecholamine concentration is the main indicator of stress response.[37] Nasotracheal intubation involves the maxillary branch of the trigeminal nerve, the glossopharyngeal nerve, the tonsil nerve, the SLN and the recurrent laryngeal nerve. The SLN is divided into the inner branch and the external branch. The external branch contains motor fibres, which travel downward with the superior thyroid artery and innervate the cricothyroid muscle. The inner branch is the sensory portion of the nerve;it passes through the thyrohyoid membrane



Group	T0	T1	T2	T3	T4
group S	83.3±8.7	85.1±9.2 *	88.2±4.9 *	85.4±8.0 *	84.2±8.4 *
group C	84.9±8.5	89.4±12.1 #	100.4±10.5 #	90.4±11.2 #	87.3±7.9 #

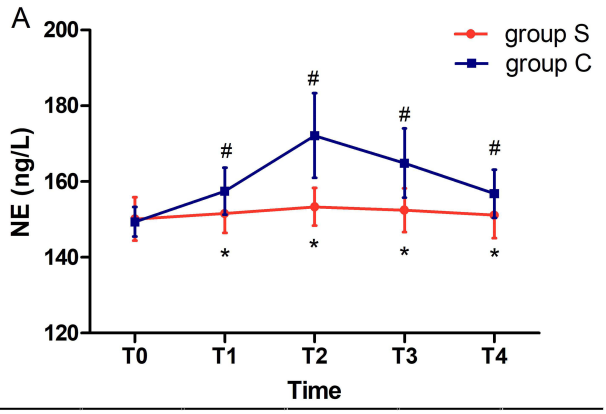


Group	T0	T1	T2	T3	T4
group S	76.9±9.5	79.2±8.7 *	84.1±6.0 *	81.5±10.9 *	79.2±11.8 *
group C	77.3±11.4	80.9±7.9 #	94.3±6.2 #	90.1±6.2 #	82.3±10.6 #

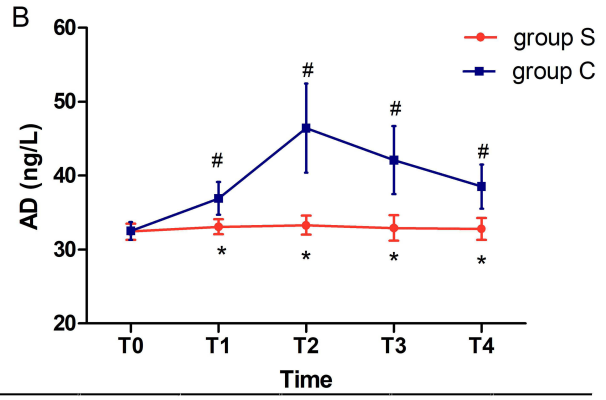
Figure 4 Comparison of the mean arterial pressure (MAP) (**A**) and heart rate (HR) (**B**) between the groups immediately before intubation (T0); immediately after intubation to the laryngopharynx (T1); and immediately (T2), 5 min (T3) and 10 min (T4) after intubation (25 patients in group S and 24 patients in group (**C**). The data are expressed as mean ± standard deviation. #Based on analysis of variance (ANOVA), compared with T0, MAP and HR in group C was significantly higher at T1, T2, T3 and T4 (P<0.05). *Based on one-way ANOVA, MAP and HR in group S was significantly lower than in group C at T1, T2, T3 and T4 (P<0.05), whereas they were not significantly higher in group S(P>0.05). Based on one-way ANOVA, there was no significant difference in MAP and HR between groups at T0 (baseline) (P>0.05). Group S received ultrasound-guided superior laryngeal nerve block; group C was the control group.

to the laryngeal cavity, and distributes to the pharynx, epiglottis, tongue base and the laryngeal mucosa above glottis rimae.[38] Therefore, SLN block should theoretically provide effective inhibition of the stress response caused by stimulation of the laryngeal mucosa, maintain haemodynamic stability and make the throat muscles relax. Moreover, UGISLNB has other advantages, including decreasing perioperative cough, sore-throat and hoarseness of voice.[39]

In group C, MAP, HR, AD and NE were significantly higher at each time point (T1–T4) compared with T0 (P<0.05), whereas they were not obviously higher in group S (P>0.05). In group S, MAP, HR, AD and NE at T1–T4 were significantly lower than in group C (P<0.05). Although it has been suggested that awake fibreoptic nasotracheal intubation could cause a stress response, UGSLNB can effectively inhibit the stress response from perioperative intubation and maintain hemodynamic stability. This mechanism may be related to blocking the internal branch of the SLN. It could block the sensation of mucosa above the tongue base, epiglottis and glottis fissure, which partly inhibits the laryngopharyngeal reflex and relaxes the vocal cords. Opening the glottis reduces its stimulation by the FB, and to some extent helps reduce the airway and cardiovascular responses. Patients could be more cooperative with the operation because they would have less discomfort, and thus poor breathing and carbon dioxide accumulation could be reduced and



Group	T0	T1	T2	T3	T4
group S	150.2±5.7	151.6±5.1 *	153.4±5.0 *	152.5±5.8 *	151.2±6.1 *
group C	149.4±3.9	157.5±6.2 #	172.2±11.2 #	165±9.1 #	156.9±6.4 #



Group	T0	T1	T2	T3	T4
group S	32.4±1.1	33.1±1.0*	33.3±1.3 *	32.9±1.7 *	32.8±1.5 *
group C	32.5±1.2	37±2.2 #	46.4±6.0 #	42.1±4.6 #	38.5±3.0 #

Figure 5 Comparison of the norepinephrine (NE) (**A**) and Adrenaline (AD) (**B**) concentrations between the groups immediately before intubation (T0); immediately after intubation to the laryngopharynx (T1); and immediately (T2), 5 min (T3) and 10 min (T4) after intubation (25 patients in group S and 24 patients in group (**C**). The data are expressed as mean ± standard deviation. #Based on analysis of variance(ANOVA) compared with T0, NE and AD in group C was significantly higher at T1, T2, T3 and T4 ($P<0.05$), but not significantly higher in group S ($P>0.05$). *Based on one-way ANOVA, NE and AD in group S was significantly lower than in group C at T1, T2, T3 and T4 ($P<0.05$). Based on one-way ANOVA, there was no significant difference in NE and AD between groups at T0 (baseline) ($P>0.05$). Group S received ultrasound-guided superior laryngeal nerve block; group C was the control group.

vital signs could be stabilised. Some studies have reported that combination of SLN block with topical airway anaesthesia produced better haemodynamic stability.[30] Uday et al[26] found that high quality of airway anaesthesia might provide better haemodynamic stability in UGSLNB group. In a randomized controlled trial, Li et al[27] demonstrated that UGSLNB blunted the haemodynamic response to a greater extent than the use of traditional local anaesthetics. Although there have been few clinical trials, our results are basically similar to previous studies. Ma et al[40] reported that the hemodynamic parameters and respiration remained stable in awake fibreoptic orotracheal intubation under SLN block. In a prospective randomized clinical study, Ambi et al[26] showed that HR and MAP were significantly more stable in the ultrasound group. Sawka et al[41] reported that five patients who underwent UGSLNB tolerated subsequent awake fibreoptic intubation with either minimal or no sedation, which indicated no evidence of incomplete anaesthesia in the distribution of SLN. Although the experimental methods were different, these results are basically consistent with our study.

Although NIPPV is preferred over invasive ventilation as the initial mode of ventilation to treat respiratory failure in patients with acute COPD exacerbation, invasive mechanical ventilation should be the first choice when NIPPV fails or

when other conditions (eg any haemodynamic instability, inability to improve dyspnoea, need to protect the airways or manage copious tracheal secretions, intolerance of mask ventilation, etc.) occur. However, our findings have put forward a new idea for effective treatment of such critically ill patients when they need endotracheal intubation.

To sum up, we presumed the possible mechanism of UGISLNB was as follows: UGISLNB successfully blocked the sensation of the mucosa above the tongue base, epiglottis and glottis fissure, the stress response was suppressed, and the laryngopharyngeal reflex was partially inhibited, as well as the vocal cords opened. As a result, the intubation could be implemented smoothly, and the intubation time was significantly shortened, which also inhibited stress response and maintained hemodynamic stability. Additionally, the incidences of adverse reactions were markedly decreased and the comfort score was significantly increased.

Limitations

This study has certain limitations. First, the sample size is small, and the findings should be confirmed with a larger sample size. Second, we used a single concentration and a single dose of local anaesthetic; additional investigations are required concerning the optimal concentration and dose of local anaesthetics. Third, some patients with difficult airways were excluded, but these patients are encountered in clinical practice. Difficult airway grades lead to different intubation times, which have a certain impact on the haemodynamic stability and comfort of patients. Furthermore, some patients with delirium or consciousness disturbance and serious respiratory distress were excluded from this study because of difficulties in performing stable ultrasound examinations. Fourth, other factors (eg blood, secretion, emesis, etc.) may obscure the fibreoptic view, which was not considered. Fifth, some demographic data and clinical data, such as the severity of COPD, lung function and underlying diseases, could not be considered, which might have influenced the results. Sixth, the deficiency of this study was that MAP, HR, NE and AD were not be recorded or monitored at UGSLNB, and the safety of UGSLNB at UGSLNB will be studied in the future. Finally, the effect of this method on the prognosis of the patients was not observed. In the future, we will continue to accumulate cases in the clinic and continue to assess its safety and applicability.

Conclusions

UGISLNB can effectively shorten the intubation time, reduce the incidence of adverse reactions, improve the comfort score, maintain haemodynamic stability and inhibit the stress response in patients with severe COPD undergoing awake fibreoptic nasotracheal intubation. Hence, this approach is worth popularising and applying in clinical practice.

Abbreviations

COPD, chronic obstructive pulmonary disease; ASA, American Society of Anaesthesiologists; UGSLNB, ultrasound-guided superior laryngeal nerve block; UGISLNB, ultrasound-guided the internal branch of the superior laryngeal nerve block; SLN, superior laryngeal nerve; FB, fibreoptic bronchoscope; ECG, electrocardiogram; MAP, mean arterial pressure; BP, blood pressure; HR, heart rate; SPO_2, saturation of peripheral oxygen; DEX, dexmedetomidine; RR, respiration rate; ETCO2, end-tidal carbon dioxide; AD, adrenaline; NE, norepinephrine; PONV, postoperative nausea and vomiting; PaO2, partial pressure of arterial oxygen; FiO_2, fraction of inspiration O_2; PaCO2, partial pressure of arterial carbon dioxide; NIPPV, non-invasive positive pressure ventilation; SD, Standard deviation; ANOVA, analysis of variance.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request in 10 months.

Ethical Statement

The authors declare that all patients gave written informed consent before initiation of the study protocol and were conducted in accordance with the Declaration of Helsinki. The study was approved by the Ethics Committee of The Second Hospital of Shandong University (No. KYLL-2020LW-057).

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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