Int J Clin Exp Med 2020;13(12):9628-9636
www.ijcem.com /ISSN:1940-5901/IJCEM0115179

*Original Article*

# The optimal concentration of lidocaine applied through a spray-as-you-go technique for surface anesthesia in bronchoscopy

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Received May 28, 2020; Accepted September 10, 2020; Epub December 15, 2020; Published December 30, 2020

**Abstract:** To explore the optimal concentration of lidocaine applied through a spray-as-you-go technique for surface anesthesia in bronchoscopy. Altogether 100 patients undergoing bronchoscopy examination in The First Affiliated Hospital of Wenzhou Medical University from March 2017 to August 2019 were enrolled and randomly assigned to a research group (n = 50) treated by 20 mL 2% lidocaine through spray-as-you-go technique based on epidural catheter, and a control group (n = 50) treated by 20 ml 1% lidocaine through the same method. The patients were scored in choking cough and also scored using the visual analog scale (VAS). The actual dose of the anesthetic drug for patients and adverse events during anesthesia were evaluated, and their vital signs were recorded. Additionally, patients' satisfaction towards the examination after recovery was also analyzed. The scores of no choking cough, 3-5 times of choking cough, and more than 5 times, in the research group were significantly lower than those of the control group and the total score of the former was significantly higher than that of the latter. The research group had a significantly lower VAS score than the control group half an hour and one hour after examination, used less anesthetic drug than the control group, and experienced significantly less adverse events than the control group. Moreover, the research group was significantly better than the control group in terms of vital signs, and the satisfaction of the research group towards the nursing staff was significantly higher than that of the control group. Two% lidocaine (20 ml) applied through the spray-as-you-go technique based on epidural catheter can effectively reduce choking cough, required dosage of anesthetic drugs, and adverse events for patients, and can also stabilize their vital signs and improve their satisfaction.

**Keywords:** Anesthesia, spray-as-you-go technique, lidocaine, bronchoscopy examination

## Introduction

Lung cancer has the highest morbidity rate and mortality rate of all cancers worldwide. According to GLOBOCAN data, there were 2.1 million new patients with lung cancer worldwide in 2018, accounting for 11.6% of all new cancer cases (ranking first), and 1.8 million deaths related to lung cancer, accounting for 18.4% of all cancer-related deaths (ranking first), and lung cancer is the main cause of cancer-related deaths in males [1, 2]. In China, lung cancer is also the malignant tumor type with the highest morbidity rate and mortality rate, and it has been listed as a cancer type requiring special prevention and treatment [3]. The poor prognosis of lung cancer is related to the late clinical stage of diagnosis in most patients, so promoting early diagnosis and treatment of lung cancer may be the main way to improve the survival rate and reduce the mortality rate of patients with the disease [4]. Bronchoscopy examination plays a crucial role in the early diagnosis of lung cancer, but as an invasive operation, bronchoscopy examination may induce suffocation, severe choking cough, laryngospasm, arrhythmia, and even cardiac arrest. Therefore, effective airway anesthesia is necessary for the application of airway instrument and comfort of patients [5].

Many patients cannot bear the procedure or do not cooperate with bronchoscopy examination, which compromises the results of the examina-

tion. The intervention of anesthesia technology significantly improves the safety and comfort of bronchoscopy examination [6-8]. Local airway anesthesia can be achieved in two ways. The first is to give the patient 2% lignin through atomizing inhalation by an ultrasonic nebulizer for about 10-15 min, and the second is to apply local anesthetic to the airway of the patient by the spray-as-you-go technique based on a bronchoscope [9]. Lidocaine is the first choice for tracheal mucosal anesthesia in bronchoscopy, because it can fully meet the needs of normal bronchoscopy, with effective cough relief performance, short half-life, high safety, and low tissue toxicity [10]. At present, anesthesia for bronchoscopy examination is mainly achieved through general anesthesia with spontaneous respiration combined with tracheal mucosal surface anesthesia, during which the patients are unconsciousness, have no memory of the examination process, and enjoy a high comfort level, but there is airway irritation that easily induces airway-related choking cough during operation and affects the quality of bronchoscopy examination [11]. Therefore, finding a comfortable, safe and painless anesthesia for bronchoscopy examination to reduce airway-related adverse reactions such as airway-related choking cough is an important goal of many scholars.

## Materials and methods

### *Basic data*

A total of 100 patients undergoing bronchoscopy examination in The First Affiliated Hospital of Wenzhou Medical University from March 2017 to August 2019 were enrolled, and randomly assigned to a research group (n = 50) and a control group (n = 50). Patients in the research group were given 20 mL 2% lidocaine through a spray-as-you-go technique based on epidural catheter, while those in the control group were given 20 ml 2% lidocaine through the same method. The research group consisted of 31 males and 19 females, with a mean age of 48.3±5.2 years, while the control group consisted of 29 males and 21 females, with a mean age of 48.5±5.1 years. This experiment was approved by the Ethics Committee of The First Affiliated Hospital of Wenzhou Medical University.

### *Inclusion and exclusion criteria*

The inclusion criteria of the patients were as follows: Patients between 18 and 65 years old, patients at I-III class in American Society of Anesthesiologists (ASA) classification, patients with normal blood routine indexes and coagulant function, patients intending to receive painless bronchoscopy examination, and those who signed informed consent forms or whose family members signed them.

The exclusion criteria of the patients were as follows: Patients with cardiac failure, hepatic or renal function, mental disease or a neurological disease history, patients with cardiac failure, patients with a history of allergy to anesthetic drugs, pregnant women, lactating women, patients lighter than 50 kg, patients with a large amount of sputum in the trachea, and those with arterial oxygen saturation ($SpO_2$) lower than 95% ($FiO_2$: 0.3 oxygen inhalation).

### *Work before examination*

General examination was carried out on each patient, which involved mental state, vital signs, situation of fasting for solid for 6-8 hours and for liquids for 3-4 hours, and use of drugs before operation. Anesthesia-related examinations were also carried out on the patient to check whether anesthesia-related examination indexes of the patient were normal, which involved electrocardiogram (ECG), pulmonary function, blood gas analysis, liver and renal function. In addition, the patient was assessed overall, and a case report form (CRF) was filled out for him/her according to possible problems in the examination and the corresponding solutions. Furthermore, specific operation procedures, anesthesia methods, and matters needing attention were introduced to the patient to enable the patient to have a certain understanding of bronchoscopy examination, and eliminate or reduce their worry and fear. Moreover, questions asked by the patient were answered in detail, and possible discomfort or complications after examination and treatment were explained to the patient.

### *Anesthesia methods*

A venous channel was established for each patient after he/she entered the examination room, and then the patient was connected

with an electrocardiomonitor to monitor the patient's continuous ECG signals, noninvasive blood pressure (NIBP), and $SpO_2$. Subsequently, the patient was given 1 mg midazolam, 10 μg sufentanil, 1 mg/kg propofol, and 0.2 mg/kg etomidate for anesthesia induction, with his/her spontaneous breathing retained. A nasopharyngeal airway was placed in one nasal cavity of the patient, and oxygen was supplied to the patient through a threaded tube of an anesthesia machine. In addition, propofol was maintained at 4 mg/kg/h by a micropump. The airway of each patient in the two groups was locally anesthetized through the spray-as-you-go technique based on epidural catheter, and the concentration of lidocaine used on patients in the research group was 1%, while that used on patients in the control group was 2%. The surface anesthesia procedure was to spray 5 ml solution to glottis, trachea, and left and right bronchi, separately. After anesthesia, bronchoscopy examination was carried out to the patient, and various indexes during the study were recorded by the anesthesia assistant. All general anesthesia and local anesthesia of the airway were performed by anesthesiologists, and bronchoscopy was carried out by respiratory physicians.

*Scoring criteria*

*Choking cough of patients during examination:* The choking cough response in the glottis, trachea, and left and right bronchi of each patient was analyzed, and the choking cough severity of the patient was scored; with 0 points for no choking cough, 1 point for 1-2 occurrences of choking cough, 2 points for 3-5 occurrences, and 3 points for more than 5 occurrences, with a total of 4 points. Zero-1 points indicated mild choking cough, 2 points indicated moderate choking cough, and 3 points indicated severe choking cough.

In addition, the satisfaction of each patient during examination was scored using the visual analog scale (VAS).

After bronchoscopy operation, the choking cough of each patient during examination was scored using VAS by the operating doctor and nurse. With a full score of 10 points, VAS is a sensitive scale, and its score is comparable. A higher VAS score indicated more serious choking cough, and poorer choking cough control result.

*Satisfaction questionnaire:* Each patient was asked to score the content of The First Affiliated Hospital of Wenzhou Medical University according to a satisfaction questionnaire developed by The First Affiliated Hospital of Wenzhou Medical University, which had a total of 20 questions, with 5 points for each question. A total score less than 70 points indicated dissatisfaction, a total score between 70 and 89 points indicated satisfaction, and a total score of 90 points or more indicated high satisfaction. Satisfaction = (the number of patients with high satisfaction + the number of those with satisfaction)/the total number of patients × 100%.

*Outcome measures*

*Primary outcome measures*: The choking cough sore and VAS score of each patient was recorded, and the actual doses of anesthetic drugs used on the two groups were also recorded. In addition, adverse events occurred during anesthesia of the two groups were evaluated, and the vital signs of the patients were recorded. The satisfaction of the patients towards the examination after recovery was also analyzed.

*Statistical analyses*

In this study, the collected data were analyzed statistically using SPSS 20.0 (IBM Corp., Armonk, NY, USA), and visualized into required figures using GraphPad 7. Data distribution was analyzed using the Kolmogorov-Smirnov (K-S) test, and data in normal distribution were expressed as the mean ± standard deviation (Mean ± SD). Comparison between groups was carried out using the independent-samples T test and comparison within groups was carried out using the paired t test. Enumeration data were expressed as the rate (%), analyzed using the chi-square test, and expressed as $X^2$. $P < 0.05$ indicates a significant difference.

## Results

*Clinical data*

There was no significant difference between the research group and the control group in

**Table 1.** Basic data [n (%)]

| | The research group (n = 50) | The control group (n = 50) | $X^2$ or t | *P*-value |
|---|---|---|---|---|
| Age (Y) | 48.3±5.2 | 48.5±5.1 | 0.192 | 0.846 |
| Marital status | | | 1.042 | 0.307 |
| Yes | 47 (94.00) | 49 (98.00) | | |
| No | 3 (6.00) | 1 (2.00) | | |
| BMI | 23.05±1.24 | 23.02±1.17 | 0.122 | 0.901 |
| Smoking history | | | 0.250 | 0.617 |
| Yes | 41 (82.00) | 39 (78.00) | | |
| No | 9 (18.00) | 11 (22.00) | | |
| Drinking history | | | 0.735 | 0.391 |
| Yes | 32 (64.00) | 36 (72.00) | | |
| No | 18 (36.00) | 14 (28.00) | | |
| Place of residence | | | 0.372 | 0.542 |
| Urban area | 28 (56.00) | 31 (62.00) | | |
| Rural area | 22 (44.00) | 19 (38.00) | | |
| Dietary favor | | | 0.364 | 0.547 |
| Light | 24 (48.00) | 21 (42.00) | | |
| Spicy | 26 (52.00) | 29 (58.00) | | |
| Exercise habit | | | 0.040 | 0.841 |
| Yes | 23 (46.00) | 24 (48.00) | | |
| No | 27 (54.00) | 26 (52.00) | | |
| Course of disease (week) | 3.74±1.04 | 3.92±0.86 | 0.943 | 0.348 |

**Table 2.** Comparison of choking cough between the two groups

| | The number of cases (n) | Choking cough score [n (%)] | | | | Total rate (%) |
|---|---|---|---|---|---|---|
| | | No choking cough | 1-2 times of choking cough | 3-5 times of choking cough | More than 5 times of choking cough | |
| The research group | 50 | 31 (62.00) | 17 (34.00) | 2 (4.00) | 0 (0.00) | 96.00 |
| The control group | 50 | 1 (2.00) | 25 (50.00) | 10 (20.00) | 14 (28.00) | 72.00 |
| $X^2$ | | 41.360 | 2.627 | 6.061 | 16.280 | 25.160 |
| *P*-value | | 0.001 | 0.105 | 0.014 | 0.001 | 0.001 |

clinical data including age, marital status, body mass index (BMI), smoking history, drinking history, place of residence, dietary favor, exercise habit, and course of disease, so they were comparable ($P > 0.05$) (**Table 1**).

*Choking cough of the patients*

The scores of no choking cough, 3-5 times of choking cough, and more than 5 times of it of the research group were significantly lower than those of the control group (all $P < 0.05$), and there was no significant difference in the score of 1-2 times of choking cough between the two groups ($P > 0.05$), but the total score of the research group was significantly higher than that of the control group ($P < 0.05$) (**Table 2**).

*VAS score of the patients*

Before examination, the VAS scores of the research group and the control group were (6.89±0.67) points and (6.87±0.65) points, respectively; at half an hour after examination, the VAS scores were (3.76±0.34) points and (5.96±0.51) points, respectively; at one hour after examination, the VAS scores of them were (1.63±0.32) points and (3.95±0.37) points, respectively. Therefore, there was no significant difference in VAS score between the two groups after examination ($P > 0.05$), while the VAS score of the research group was significantly lower than that of the control group half an hour and one hour after examination ($P < 0.05$) (**Figure 1**).

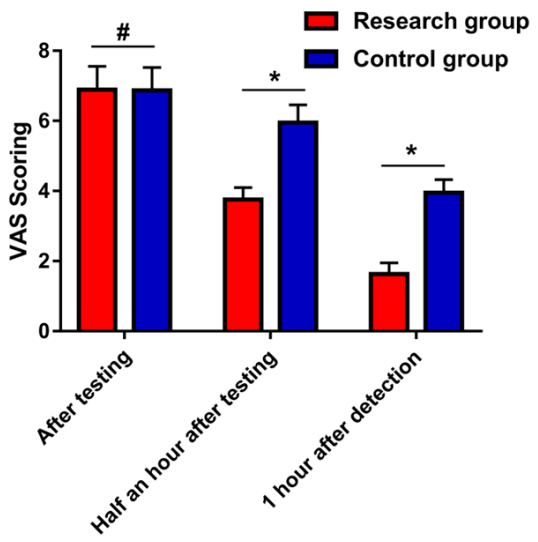


**Figure 1.** VAS score of the patients. The VAS score of the research group was significantly lower than that of the control group half an hour after examination and one hour after examination ($P < 0.05$). Note: # indicates that there was no difference between the two groups ($P > 0.05$), and * indicates that there were differences between the two groups ($P < 0.05$).

*Actual dose of anesthetic drug used on the two groups and the occurrence of adverse events of the patients during anesthesia*

The dose of anesthetic drug used on the research group was less than that used on the control group ($P < 0.05$), and the total incidence of adverse events in the research group was significantly lower than that in the control group ($P < 0.05$) (**Figure 2** and **Table 3**).

*Vital signs of the patients*

Vital signs of patients in the two groups were evaluated and recorded in real time, and it was found that the research group performed significantly better than the control group in vital signs including heart rate, pulse, blood pressure, and blood oxygen (all $P < 0.05$) (**Figure 3**).

*Satisfaction of patients towards detection after resuscitation*

The satisfaction of the research group towards the nursing staff was significantly higher than that of the control group (98.00% *vs.* 70.00%, $P < 0.05$) (**Table 4**).

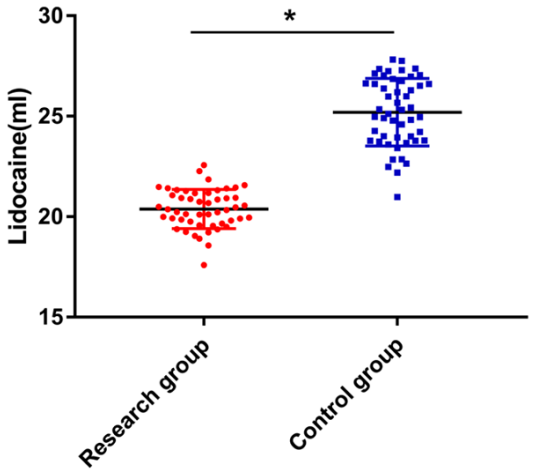


**Figure 2.** Dosage of anesthetic drug. The dose of anesthetic drugs used on the research group was significantly less than that used on the control group ($P < 0.05$). Note: * indicates that there were differences between the two groups ($P < 0.05$).

## Discussion

Lung cancer is an invasive and heterogeneous disease [12]. The World Health Organization estimates that 71% of lung cancer is caused by smoking, and over 400,000 people die of lung cancer every year due to smoking [13]. As the etiology and pathogenesis of lung cancer are still under investigation, studying lung cancer and diagnosing and treating it as early as possible are the primary objectives to reduce the incidence and mortality rate of the cancer [14]. At the end of last century, flexible bronchoscopy examination was considered to be one of the most commonly used methods for airway examination by physicians of different disciplines [15]. Graham et al. [16] have pointed out that fiber bronchoscopy examination is carried out by a pulmonary physician or anesthesiologist. In many causes, fiber bronchoscopy examination is carried out only after local anesthesia, without any sedative measures. Such a simplified method is safe, and can reduce expenditure. One study by Chandra et al. [17] has indicated that 50% of patients choose intravenous anesthesia, but intravenous anesthesia requires sufficient anesthetic and causes a relatively high incidence of adverse events. Intravenous sedation limits the dynamic analysis of the airway, such as vocal cords, presence of local or diffuse malacia, and effects of choking cough.

**Table 3.** Adverse events [n (%)]

| Item | The research group (n = 50) | The control group (n = 50) | $X^2$ | *P*-value |
|---|---|---|---|---|
| Suffocation | 1 (2.00) | 2 (4.00) | | |
| Severe choking cough | 1 (2.00) | 5 (10.00) | | |
| Laryngospasm | 0 (0.00) | 2 (4.00) | | |
| Arrhythmia | 0 (0.00) | 2 (4.00) | | |
| Cardiac arrest | 1 (2.00) | 4 (8.00) | | |
| The total incidence | 3 (6.00) | 15 (30.00) | 9.756 | 0.002 |

For patients, fiber bronchoscopy examination is very uncomfortable. Most patients suffer from nervous anxiety and fear of bronchoscopy and bronchoscopy is an invasive operation that invades the airway, causing severe cough, suffocation, and severe hypoxia, so it needs assistance of certain anesthesia [18]. However, general intravenous anesthesia alone cannot meet the requirements of bronchoscopy examination, under which patients still suffer from physiological reflex and choking cough in the airway, so local anesthesia is also required. The tolerance of patients to the bronchoscopy is largely determined by the effect of local anesthesia, and the spray-as-you-go technique is the most commonly and widely accepted method for delivering local anesthetic drugs to the vocal cords and airway [19]. Therefore, we tried to provide reference for clinical application by studying and discussing local anesthetic administration method of the spray-as-you-go technique based on epidural catheter.

In this study, we firstly analyzed the choking cough of the patients, finding that the scores of no choking cough, 3-5 times of choking cough, and more than 5 times in the research group were significantly lower than those of the control group, implying that the spray-as-you-go technique can effectively reduce the choking cough of the patients. In addition, we scored the choking cough severity of the patients using VAS, finding that there was no significant difference between the two groups in VAS score after examination, while the VAS score of the research group was significantly lower than that of the control group half an hour and one hour after examination. One study has revealed that excessively high blood concentration of lidocaine is accompanied by more severe side effects [20], and one study by Hasmoni and Bansal et al. [21, 22] has revealed that lidocaine can effectively alleviate cough. In this study, it was found by observing the adverse reactions of the patients that the total incidence of adverse reactions of the research group was only 6%, while that of the control group was up to 30%, which further verified the reliability of the spray-as-you-go technique. At the end of the study, we performed statistics on the vital signs and satisfaction of the patients, finding that the research group performed significantly better than the control group in vital signs including heart rate, pulse, blood pressure, and blood oxygen, and the satisfaction of the research group was higher than that of the control group according to the satisfaction questionnaire developed by The First Affiliated Hospital of Wenzhou Medical University. The application of lidocaine through the spray-as-you-go technique for surface anesthesia of bronchoscopy is of clinical significance and worthy of clinical promotion.

Through the above study, we have preliminarily verified that 2% lidocaine (20 ml) applied by the spray-as-you-go technique based on epidural catheter can effectively reduce choking cough, the required dosage of anesthetic drugs, and adverse events for patients, and can stabilize their vital signs and improve their satisfaction. However, there are still some limitations in this study. For example, we have not followed the patients to understand their prognosis. Therefore, we will follow the patients in future studies to expand the comprehensiveness of our study and supplement our research results.

To sum up, for patients after surgery, 2% lidocaine (20 ml) applied by the spray-as-you-go technique based on epidural catheter can effectively alleviate choking cough, reduce adverse events, stabilize vital signs, and improve treatment satisfaction.

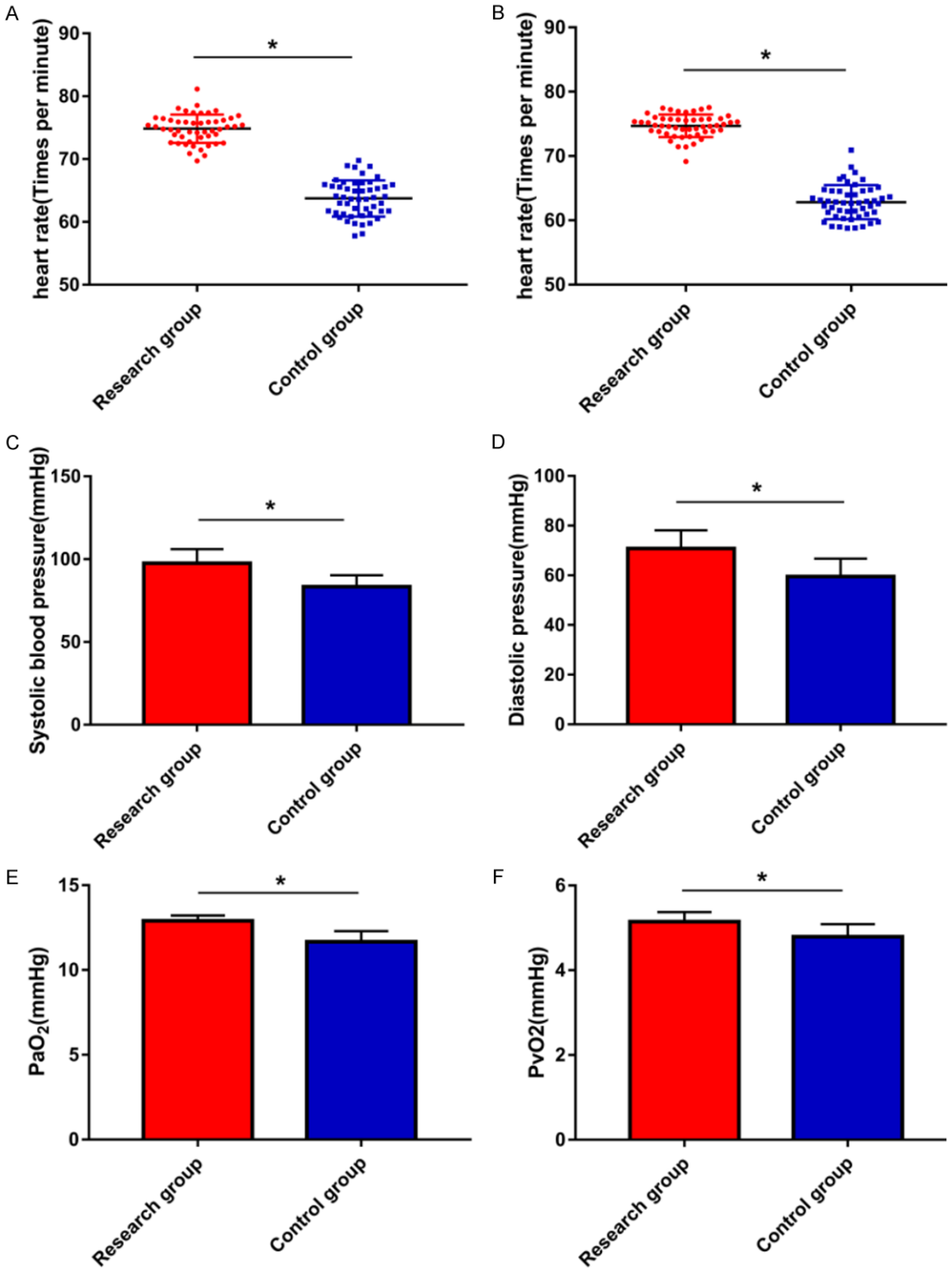


**Figure 3.** Vital signs. A, B. The heart rate of the research group was significantly better than that of the control group. C. The diastolic blood pressure of the research group was significantly better than that of the control group. D. The systolic blood pressure of the research group was significantly better than that of the control group. E. The $PaO_2$ of the research group was significantly better than that of the control group. F. The $PvO_2$ of the research group was significantly better than that of the control group. Note: * indicates a difference between the two groups ($P < 0.05$).

**Table 4.** Nursing satisfaction score [n (%)]

| Group | The number of patients | Satisfaction | Moderate satisfaction | Dissatisfaction | Satisfaction degree (%) |
|---|---|---|---|---|---|
| The research group | 50 | 39 (78.00) | 10 (20.00) | 1 (2.00) | 49 (98.00) |
| The control group | 50 | 10 (20.00) | 25 (50.00) | 15 (30.00) | 35 (70.00) |
| t | | | | | 14.580 |
| *P*-value | | | | | 0.001 |

## Acknowledgements

The study was financially supported by Wenzhou Science & Technology Bureau (Y2019-0510).

## Disclosure of conflict of interest

None.

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