Progress in Medical Education
ISSN: 3007-0007

Zentime

Research Article https://doi.org/10.61189/937243auxvcj

Efficacy of visual double-lumen bronchial catheter in teaching lung isolation

Minhao Zhang[1], Halisa Paerhati[2], Miao Zhou[1], Jiahui Chen[3], Zhiyan Wang[4], Lianbing Gu[1], Pengyi Li[1]

[1]Department of Anesthesiology, Jiangsu Cancer Hospital, Jiangsu Institute of Cancer Research, the Affiliated Cancer Hospital of Nanjing Medical University, Nanjing 210009, Jiangsu Province, China. [2]Department of Anesthesiology, the Affiliated Cancer Hospital of Nanjing Medical University, Jiangsu Cancer Hospital, Nanjing 210009, Jiangsu Province, China. [3]Affiliated Anesthesia College of Xuzhou Medical University, Xuzhou 221004, Jiangsu Province, China. [4]Department of Nursing, Jiangsu Cancer Hospital, Jiangsu Institute of Cancer Research, the Affiliated Cancer Hospital of Nanjing Medical University, Nanjing 210009, Jiangsu Province, China.

Corresponding author: Pengyi Li.

Declaration of conflict of interest: None.

Received December 4, 2024, Accepted March 3, 2025, Published April 1, 2025

Highlights

- The study highlights the effective integration of visual double-lumen bronchial catheters in anesthesia residency training. It significantly shortens intubation time, enhances first-attempt success rates and surgeon satisfaction.
- This approach notably reduces post-intubation complications, including pharyngeal pain, hoarseness, and dry cough, leading to better patient outcomes and enhanced educational efficacy.

Abstract

Objective: To assess the effectiveness of a visual double-lumen bronchial catheter in teaching lung isolation skills to anesthesia resident trainees. **Methods:** Between September 2023 and September 2024, 20 anesthesiology residents from Jiangsu Cancer Hospital were randomly divided into two groups: the visual double-lumen group (n=10) and the conventional double-lumen group (n=10). Randomization was achieved using a random number table. The study assessed several outcomes, including total intubation time, positioning time, one-time intubation success rate, intraoperative catheter displacement rate, surgeon satisfaction scores, and the incidence of postoperative complications (pharyngeal pain, hoarseness, and dry cough) within 24 hours. **Results:** The visual double-lumen group demonstrated superior results compared to the conventional double-lumen group in the following measures: total intubation time (70.2±11.8 s vs 224.9±35.6 s), positioning time (30.1±5.7s vs 176.6±26.4 s), one-time intubation success rate (85% vs 45%), intraoperative catheter displacement rate (10% vs 40%), surgeon's intubation satisfaction score (8.10±1.07 vs 6.90±1.41), satisfaction score for pulmonary isolation (8.35±1.04 vs 6.55±1.36), and airway management satisfaction score (8.40±1.3 vs 6.70±1.34). Additionally, the incidence of postoperative pharyngeal pain (15% vs 45%), hoarseness (10% vs 40%), and dry cough (5% vs 35%) was significantly lower in the visual double-lumen group (all $P<0.05$). **Conclusion:** The visual double-lumen bronchial catheter significantly enhances the training of anesthesia residents in lung isolation by reducing intubation and positioning times, improving intubation success rate, increasing surgeon satisfaction, and reducing intubation-related complications. This method offers a more effective teaching approach compared to conventional techniques.

Keywords: Visual double-lumen catheter, pulmonary isolation, educational techniques, teaching effect, standardized residency training

Introduction

Tracheal intubation is essential for establishing an artificial airway to facilitate mechanical ventilation, meeting the demands of most clinical anesthesia and emergency scenarios. However, the rhythmic expansion and contraction of lung tissue during respiration can compromise the surgical field and operating space. Consequently, procedures involving the lungs, esophagus, mediastinum, pleura, trachea, and other thoracic structures necessitate techniques that

Address correspondence to: Pengyi Li, Department of Anesthesiology, Jiangsu Cancer Hospital, Nanjing 210009, Jiangsu Province, China. Tel: +86-18252057979, Email: lipengyi@njmu.edu.cn.

collapse one lung while maintaining ventilation in the contralateral lung, a technique known as lung isolation.

The double-lumen bronchial tube is the most commonly used tool for lung isolation [1]. However, its relatively large diameter, precise positioning requirements, and operational complexity can lead to complications such as tooth loss, airway injury, cricoarytenoid joint dislocation, and glottic edema [2]. These risks are exacerbated due to the inexperience of resident physicians, which increases their psychological pressure and negatively impacts their learning efficiency. Clinically, positioning double-lumen bronchial tubes can be performed through auscultation or fiberoptic bronchoscopy [3]. While auscultation is less accurate, fiberoptic bronchoscopy demands advanced skills, making it difficult for trainees to quickly correct errors. In addition, fiberoptic bronchoscopy is reusable and involves invasive procedures, which poses a risk of hospital-acquired infections [4]. Furthermore, the assessment of trainees' operational skills primarily relies on subjective judgment from instructors, lacking standardized criteria. This approach tends to focus on procedural success while neglecting complication prevention and management, hindering comprehensive skill development. Anesthesiologists typically require extensive practice to master lung isolation techniques, which is constrained by training duration and case availability. Therefore, effectively training residents in lung isolation techniques is an pressing issue in standardized anesthesiology residency training.

With advancements in visualization technology, the use of visual double-lumen bronchial tubes in lung isolation surgery is becoming more prevalent. The camera at the catheter's tip enables direct visualization during bronchial intubation and positioning, improving intubation efficiency and facilitating early detection of catheter displacement [5]. Previous studies have shown that anesthesiologists using visual double-lumen bronchial tubes for lung isolation significantly reduce intubation time, increase intubation success rates, enable early detection of intraoperative catheter displacement, and decrease the reliance of fiberoptic bronchoscopy as well as intubation-related complications [6]. This study aims to evaluate the application value of visual double-lumen bronchial tubes in lung isolation training and assess their educational impact on anesthesiology residency training. Specifically, it investigates the teaching effectiveness of visual double-lumen bronchial tubes in this context.

Materials and methods

General information of residents in the two groups

From September 2023 to September 2024, 20 trainees were selected from the standardized anesthesia residency training program at Jiangsu Provincial Cancer Hospital. To ensure random allocation, a random number table method was employed. Each trainee was assigned a unique identifier, and a random number generator was used to generate corresponding random numbers. Based on the values of these numbers, trainees were assigned to either the visual double-lumen bronchial intubation group or the conventional double-lumen bronchial intubation group, with 10 trainees in each group.

Inclusion criteria: (1) Full-time undergraduate students majoring in clinical medicine or anesthesiology; (2) Currently undergoing standardized residency training, including professional graduate students and socialized resident trainees; (3) Completion of at least three months of training in the anesthesiology department, with proficiency in tracheal intubation but no prior training in double-lumen bronchial intubation. Exclusion criteria: (1) Unwillingness to participate in the study; (2) Non-right-handed individuals.

General information of patients undergoing pulmonary isolation in the two groups

The study was approved by the Ethics Committee of Jiangsu Cancer Hospital, and informed consent was obtained from all participants. The inclusion criteria for patients: (1) Age between 18 and 64 years, scheduled for elective right-sided partial lung resection; (2) Classification of American Society of Anesthesiologists (ASA) class I or II; (3) Body mass index (BMI) less than 28 kg/m^2. Exclusion criteria: (1) Upper respiratory tract infection within two weeks prior to surgery; (2) Difficult or suspected difficult airway; (3) Preoperative CT scan indicating a difficult airway; (4) Preoperative CT scan showing abnormal respiratory tract anatomy; (5) Presence of underlying diseases such as asthma or severe cardiac insufficiency; (6) Preoperative symptoms of pharyngeal pain, hoarseness, or dry cough; (7) Operation duration exceeding 3 hours or less than 1 hour; (8) Postoperative admission to the ICU for further treatment. A total of 40 patients were enrolled, with 20 patients in each group.

In the conventional double-lumen catheter

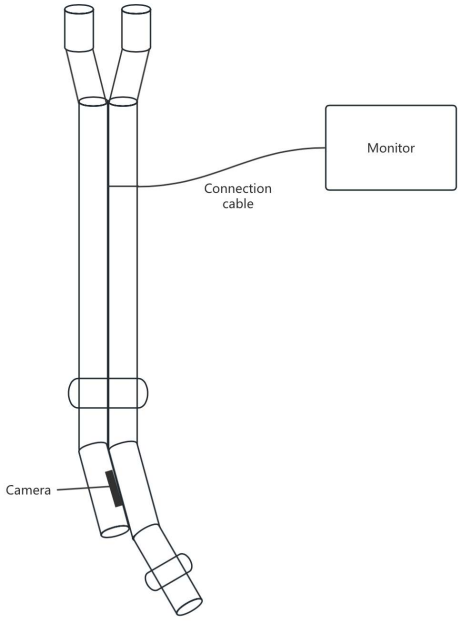

Figure 1. Schematic diagram of a visual double-lumen bronchial catheter.

Figure 2. Camera on the front of the visual dual-lumen bronchial catheter.

group, there were 8 males and 12 females, aged 33 to 61 years, with a mean age of 48.5±9.8 years, a BMI range of 20.5 to 25.8 kg/m², and a mean BMI of 24.2±3.0 kg/m². ASA classification was class I in 8 cases and class II in 12 cases. In the visual double-lumen catheter group, there were 10 males and 10 females, aged 30 to 63 years, with a mean age of 50.3±11.4 years, a BMI range of 22.0 to 25.6 kg/m², and a mean BMI of 23.3±3.4 kg/m². ASA classification was class I in 7 cases and class II in 13 cases. No significant differences were found between the two groups regarding gender composition, age, BMI, and ASA classification (all P>0.05).

Preoperative teaching preparation

On the eve of surgery, the instructor initially guided the resident trainees in reviewing the patient's medical records and previewing the proposed surgical and anesthetic procedures. The trainees were instructed to meticulously examine the patient's chest CT scans to assess any anatomical anomalies of the airway, measure the dimensions of the trachea and bronchus, and select the appropriate left-sided double-lumen bronchial catheter. Subsequently, the instructor elucidated the principles of airway anatomy, detailed the structural differences between conventional and visual double-lumen bronchial tubes (**Figure 1-2**), and outlined the steps involved in intubation, fiberoptic bronchoscopy, and tube positioning techniques. Ultimately, the instructor conducted a live demonstration of the procedures, after which each resident trainee practiced the maneuvers ten times using simulation teaching aids. On the day of surgery, under the supervision of the teaching staff, each resident trainee performed double-lumen bronchial intubation on two patients.

Double-lumen bronchial intubation procedure

The distal end of the left double-lumen bronchial tube were thoroughly lubricated with sterile lubricant, ensuring that the lubricant does not contact the camera lens of the visual double-lumen tube to prevent blurring. The visual double-lumen tube's cable was connected to the monitor to ensure a clear and smooth image. The double-lumen catheter was shaped according to the patient's body habitus and the curvature of the disposable video laryngoscope blade. After anesthesia induction, the trainee, under instructor supervision, held the video laryngoscope in the left hand and inserted it into the patient's oral cavity. The blade was gradually centered and gently advanced to the junction of the epiglottis and the base of the tongue to visualize the epiglottis. The video laryngoscope was elevated to exposes the vocal cords.

Conventional Double-Lumen Catheter Group: With the right hand, the left double-lumen bronchial catheter was held in a pen-like grip and inserted along the blade from the patient's right oral corner, aligning the beveled end with the vocal cords. Once the branch end passes through the vocal cords, the stylet was removed and rotated 90 degrees to the right and gently advanced. For males, advance the catheter to 29-31 cm from the incisors, and for females, to 27-29 cm, stopping when resistance is felt. A fiberoptic bronchoscope was used to adjust the catheter's position; When inserting the bronchoscope through the right lumen, the carina and the openings of the right upper, middle,

Table 1. Comparison of demographic data between two groups of residents (n, %)

Group	Age (years)	Male [n (%)]	Female [n (%)]	Postgraduate Residents [n (%)]	Socialized Residents [n (%)]
Visual Double-Lumen Catheter Group (n=10)	25.00±1.90	2 (20%)	8 (80%)	9 (90%)	1 (10%)
Conventional Double-Lumen Catheter Group (n=10)	24.70±1.60	3 (30%)	7 (70%)	8 (80%)	2 (20%)
t/χ^2	0.387	0.268		0.392	
P-value	0.703	1.000		1.000	

Figure 3. Image of the visual dual-lumen bronchial catheter monitor.

and lower lobar bronchi should be visible, as well as the blue cuff of the left main bronchus below the carina; when inserting through the left lumen, the openings of the left upper and lower lobar bronchi should be visible [7]. Securely fix the double-lumen bronchial catheter after satisfactory positioning.

Visualized Double-Lumen Catheter Group: Following the same initial procedures as the conventional group, the stylet was removed, and the double-lumen tube was slowly advanced. When the monitor shows that the catheter's tip is nearing the carina, rotate the tube to the left and insert the tip directly into the left main bronchus under direct vision. Once only the edge of the blue cuff is visible on the monitor (**Figure 3**), secure the double-lumen tube properly [8].

Observation indicators

The duration from the insertion of the laryngoscope by the resident trainee to the securing of the double-lumen tube was recorded, referred to as the total intubation time. Additionally, the period from the entry of the double-lumen tube into the vocal cords and the removal of the plastic stylet to the completion of the tube's positioning was documented, termed positioning time. Data on total intubation time, positioning time, first-attempt intubation success rate, and intraoperative catheter displacement rate were collected for both participant groups. Postoperatively, the surgeon was asked to provide a satisfaction score across three aspects: intubation satisfaction, pulmonary isolation satisfaction, and airway management satisfaction. Each category was rated on a scale from 0 to 10, with 10 indicating the highest level of satisfaction. Patients were followed up within 24 hours after surgery to document the incidence of pharyngeal pain, hoarseness, and dry cough.

Statistical methods

Statistical analyses were conducted using SPSS 22.0 software. Continuous data were expressed as mean ± standard deviation, and between-group comparisons were performed using the independent samples t-test. Categorical data were analyzed using the chi-squared (χ^2) test. A p-value of less than 0.05 was considered statistically significant.

Results

Comparison of demographic characteristics between two groups of residents

A demographic comparison, including age, gender distribution, and educational background, between the two cohorts of resident trainees showed no statistically significant differences ($P>0.05$) (**Table 1**).

Comparison of intubation outcomes between the visual double-lumen catheter group and the conventional double-lumen catheter group

The visual double-lumen catheter group demonstrated significantly shorter total intubation and positioning times than the conventional double-lumen catheter group (both $P<0.05$). Additionally, the first-attempt intubation success rate was significantly higher in the visual double-lumen catheter group compared to the conventional group ($P<0.05$). Furthermore, the incidence of intraoperative catheter displacement was significantly lower in the visual double-lumen catheter group than in the conventional group ($P<0.05$) (**Table 2**).

Comparison of surgeon satisfaction scores

Table 2. Comparison of intubation outcomes between the two groups of patients (mean ± SD; n (%))

Group	Total Intubation Time (s)	Positioning Time (s)	First-Attempt Intubation Success Rate [n (%)]	Intraoperative Catheter Displacement Rate [n (%)]
Visual Double-Lumen Catheter Group (n=20)	70.20±11.80	30.10±5.70	17 (85%)	2 (10%)
Conventional Double-Lumen Catheter Group (n=20)	224.90±35.60	176.60±26.40	9 (45%)	8 (40%)
t/χ^2	18.433	24.228	7.033	4.800
P-value	0.000	0.000	0.008	0.028

Table 3. Comparison of surgeon satisfaction scores between the two groups (mean ± SD)

Group	Intubation Satisfaction Score	Lung Isolation Satisfaction Score	Airway Management Satisfaction Score
Visual Double-Lumen Catheter Group (n=20)	8.10±1.07	8.35±1.04	8.40±1.23
Conventional Double-Lumen Catheter Group (n=20)	6.90±1.41	6.55±1.36	6.70±1.34
t/χ^2	1.407	1.193	0.202
P -value	0.004	0.000	0.000

Note: Satisfaction scores are presented as mean ± SD. A higher score indicates greater satisfaction, with a maximum possible score of 10 for each category.

Table 4. Comparison of post-intubation complications between the two groups of patients

Group	Pharyngeal Pain [n (%)]	Hoarseness [n (%)]	Dry Cough [n (%)]
Visual Double-Lumen Catheter Group (n=20)	3 (15%)	2 (10%)	1 (5%)
Conventional Double-Lumen Catheter Group (n=20)	9 (45%)	8 (40%)	7 (35%)
t/χ^2	4.286	4.800	3.906
P-value	0.038	0.028	0.048

The surgeon's satisfaction scores for intubation, lung isolation, and airway management were significantly higher in the visual double-lumen catheter group compared to the conventional double-lumen catheter group (all P<0.05) (**Table 3**).

Comparison of post-intubation complications between the visual double-lumen catheter group and the conventional double-lumen catheter group

The incidence of post-intubation complications, including pharyngeal pain, hoarseness, and dry cough, was significantly lower in the visual double-lumen catheter group compared to the conventional double-lumen catheter group (all P<0.05) (**Table 4**).

Discussion

Double-lumen tubes are commonly used for lung isolation during thoracic surgery. However, their larger diameter presents a greater challenge for intubation compared to standard single-lumen tracheal tubes. Repeated intubation attempts and positional adjustments can cause damage to the teeth, oropharynx, vocal cords, and tracheal mucosa, with severe cases potentially resulting in tracheal rupture [9]. In practice, the anatomical characteristics of the right main bronchus—its steep and straight configuration, thick and short structure, and the high position of the right upper lobe bronchus, often result in the misplacement of left double-lumen bronchial catheters into the right side or improper alignment of right double-lumen bronchial catheters within the right upper lung. Additionally, factors such as changes in patient positioning, surgical manipulation, and intraoperative secretion obstruction can compromise lung isolation, necessitating operation interruptions and re-initiation of lung isolation [10]. Clinically, the placement of double-lumen bronchial catheters primarily relies on auscultation and fiberoptic bronchoscopy. Auscultation often fails to accurately determine the depth or position of the tube, resulting in suboptimal localization precision [11]. Although fiberoptic bronchoscopy is considered the gold standard for lung isolation localization, it is costly, scarce in many healthcare settings, requires physicians to possess advanced anatomical knowledge and technical skill. Furthermore, the cumbersome processes for cleaning, disinfection, sterilization, storage, maintenance, and repair limit its widespread clinical application [12]. These challenges make DLT intubation particularly difficult for resident trainees to master [13].

With the ongoing advancement of medical technology, visualization in teaching has become increasingly integrated into anesthesia education, helping students better understand the complex procedures [14]. Research by Niu Lijun et al. indicated that the use of light rods in visualizing tracheal intubation teaching significantly enhances the success rate of tracheal intubation among clinical interns [15]. A study by Zhou et al. demonstrated that ultrasound-guided teaching for truncal nerve blocks greatly boosts student motivation, improves teaching safety and efficiency, and achieves ideal and standardized teaching outcomes [16]. In a study by Feng et al., the application of visual laryngoscopy for teaching tracheal intubation to non-anesthesia residents provided clear visualization of pharyngeal anatomy, thereby improving the first-time intubation success rate of the trainees [17].

The visual dual-lumen bronchial catheter is an innovative tool for lung isolation, distinguishing itself from traditional dual-lumen bronchial catheters by incorporating an LED light source and a high-resolution camera at its distal end. This design enables real-time imaging of the airway during intubation and throughout the surgical procedure, with images transmitted to an external monitor [5]. As a result, anesthesiologists can precisely identify the carina, as well as the left and right main bronchi, during intubation, allowing for accurate adjustments in the direction and depth of the double-lumen catheter. This minimizes issues such as malpositioning and excessive catheter depth [18].

The study findings indicate that resident trainees required less time, achieved a higher first-attempt intubation success rate, and experienced a lower incidence of intraoperative catheter displacement when using the visual dual-lumen bronchial catheter for direct intubation and positioning. These results suggest superior performance in teaching lung isolation techniques, with a greater likelihood of students acquiring proficiency in these skills. Moreover, the anterior camera of the visual catheter allows for continuous monitoring of both the catheter's position and airway secretions throughout the procedure. If catheter displacement occurs, surgeons can promptly reposition the catheter without interrupting surgery and efficiently clear airway secretions, facilitating postoperative pulmonary rehabilitation [19, 20].

Additionally, the study demonstrated that using a visual double-lumen catheter reduces irritation to the vocal folds and airway mucosa caused by repeated catheter adjustments. Patients experienced a significantly lower incidence of postoperative pharyngeal pain, hoarseness, and coughing, with improved surgeon satisfaction regarding intubation, lung isolation, and airway management. This suggests that teaching lung isolation with a visual double-lumen catheter not only reduces patient-related complications but also enhances surgeon satisfaction.

To achieve optimal outcomes during the visual double-lumen catheter placement, several key points must be noted:

• Preoperative Preparation: Thorough preparation is crucial. Instructors must guide students to review the patient's medical history and surgical plan in advance to fully understand the anesthesia strategy. Students are advised to consult relevant literature to familiarize themselves with the procedure and identify appropriate moments for collaboration with the surgeon. This includes tasks such as deepening anesthesia, suctioning secretions, disconnecting the respirator, initiating and terminating lung isolation, and assisting with lung positioning.

• Understanding Airway Anatomy: Students must have a deep understanding of airway anatomy. The tracheal cartilage is "C"-shaped, and the tracheal membrane wall, located in the dorsal notch of the tracheal cartilage, is composed of smooth muscle and connective tissue. Recognizing this wall is key to identifying the left and right main bronchi. Mastery of airway anatomy enables students to anticipate positioning challenges and quickly adjust the catheter if displacement occurs during surgery.

• Interpretation of Chest CT Scans: It is crucial for students to develop the ability to interpret chest CT scans. These scans reveal variations, stenosis, compression, and diverticula in the trachea and bronchi, as well as the angles, lengths, and diameters of the right and left main bronchi and trachea. Such information helps anticipate potential issues before intubation [21]. Additionally, three-dimensional airway reconstructions, available in some hospitals, can assist students in visualizing the extent of surgical resection and bronchial alignment, further enhancing their understanding of airway anatomy and double-lumen catheter placement [22].

• Individualized Anesthesia: Precision in anesthesia is critical for optimal patient recovery. Traditionally, anesthesiologists select double-lu-

men catheter models based on gender, height, and weight; however, this approach is imprecise. In adults, particularly women, tracheal length and diameter do not strongly correlate with height [23]. An oversized catheter may become lodged under the glottis, causing tracheal mucosa damage or even rupture in severe cases. Conversely, an undersized catheter may fail to adequately seal the bronchus after inflation, leading to lung isolation failure and increased risk of catheter displacement during positional changes or surgical manipulation [24]. Therefore, it is recommended to measure the length and diameter of the patient's trachea and main bronchus via chest CT to select a more appropriate double-lumen catheter model, achieving personalized and refined anesthesia [25].

While the visual double-lumen bronchial tube offers distinct advantages, it also presents several limitations. Firstly, its high cost, coupled with the requirement for additional monitoring systems in certain cases, increases expenses for medical institutions, limiting its widespread adoption. Secondly, its global availability is low, market demand is limited, and the range of indications is narrow, constraining opportunities for acquisition and utilization. Lastly, the fixed camera at the tube's front end is non-adjustable, resulting in a restricted field of view; and technical failures can impede emergency management.

Our study demonstrates that even with direct-vision placement of visual double-lumen bronchial tubes, reverse insertion can occur, which is a common issue in clinical practice. Therefore, it is imperative to analyze the causes and instruct students in proper management techniques. The primary cause often relates to the acute angle between the main bronchus and the trachea, along with significant twisting and displacement of the bulge. This issue can be addressed by gently retracting the catheter over the rongeur, followed by rotation and insertion into the contralateral bronchus. If repeated attempts are unsuccessful, intubation should be performed under fiberoptic bronchoscopic guidance [26]. During surgery, gentle maneuvers are crucial to prevent serious damage to the patient's vocal folds and airway. Intraoperative tracheal displacement was observed in both groups, associated with the patient's lateral position and surgical manipulation. Thus, when positioning the patient laterally, students must re-evaluate the double-lumen catheter's position and make timely adjustments. Visual impairment associated with the use of a visual double-lumen bronchial catheter can occur due to airway secretions or intraoperative bleeding that obscures the camera. In such cases, a suction tube may be utilized to aspirate secretions or blood near the lens. Alternatively, a small amount of saline can be introduced to flush the lumen and then promptly aspirated.

In the educational process, instructors should prioritize the psychological well-being of resident trainees. Studies indicate that the prevalence of depression among Chinese medical students is as high as 14.1% [27]. Resident trainees, balancing dual roles as students and residents, face multiple pressures during their training, including a fast-paced work environment, long working hours, strained doctor-patient relationships, burnout, extensive learning content, frequent examinations, lack of sleep, and insufficient exercise. These challenges can overwhelm junior trainees who have recently graduated. A survey of 284 resident trainees revealed significant psychological stress, with employment, academic work, financial, and emotional stress being major contributors [28]. When performing complex clinical procedures such as lung isolation, resident trainees may experience psychological stress, nervousness, and a lack of self-confidence. Surrounded by peers or surgeons and confronted with operational mishaps, they may become disorganized and falter, leading to operational failure and a cycle of self-negation that affects subsequent training. Consequently, educators should support students, understand their psychological state, assist with life challenges, provide timely psychological counseling, and refine teaching methods to enhance learning and mastery of clinical skills.

Limitations

Firstly, the sample size in this study was small, consisting of only 20 residents undergoing standardized training at a single center. As a result, individual differences may have influenced the outcomes. Secondly, the study did not include non-right-handed residents. This exclusion was based on differences in operating habits, hand coordination, and tool usage between right-handed and non-right-handed individuals. To ensure data comparability and minimize operational biases, it is important to control for handedness as a variable in research. Furthermore, most visible double-lumen tubes and their auxiliary tools (e.g., video laryngoscopes and control buttons) are designed for right-handed users. Therefore, non-right-handed individuals may experience decreased operational efficiency or accuracy during their practice. Finally, this study focused only on training with left-sided visual double-lumen tubes, and

all patients included had stable health conditions. There is a lack of research addressing training with right-sided visible double-lumen tubes or in patients with difficult airways.

Conclusions

In summary, the use of visual double-lumen catheters in lung isolation training can significantly reduce both the total intubation time and the positioning time for resident trainees. It also enhances the success rate of first-attempt intubations, improves surgeon satisfaction, and reduces intubation-related complications. To achieve optimal teaching outcomes, instructors must guide trainees through comprehensive preoperative preparation, instruct them in proper handling techniques, and remain attentive to their psychological well-being. This approach is clinically viable and yields precise educational results.

Future research should consider conducting longitudinal studies to assess the long-term impact of visual double-lumen catheter training in clinical practice. Such studies would provide insights into the retention of acquired skills and determine whether this training sustainably enhances the accuracy and safety of medical procedures. Additionally, further research could explore strategies to optimize training methods and improve the clinical adoption of visual double-lumen catheters. Interdisciplinary collaboration, incorporating modern technologies such as artificial intelligence and virtual reality, may offer innovative approaches to training in this field. These advancements could lead to more effective training programs for medical professionals, ultimately enhancing patient care quality and clinical outcomes.

Author contributions: Pengyi Li was responsible for the overall conception and design of the paper. Lianbing GU and Miao Zhou contributed to make suggestions for the research. Pengyi Li and Minhao Zhang performed the experiment and data analyses, wrote the manuscript. Halisa Paerhati, Jiahui Chen and Zhiyan Wang collected the data. Halisa Paerhati provided assistance in data analyses and manuscript correction.

References

[1] Chen XZ, Wang B. Methods and progress of lung atrophy and pulmonary reanimation with one-lung ventilation. J Hebei Med Univ 2023;44(09):1108-1113.

[2] Zou GS, Yang J, Feng ZG. Double-lumen endotracheal tube versus bronchial blocker in one lung ventilation. J Clin Anesthesiol 2012;28(06):557-559.

[3] Zhao J. Research Progress on the Positioning Methods of Double-Lumen Bronchial Tubes. Chin Med Device Inf 2019;25(10):21-22.

[4] Zhang SQ, Xin RF, Peng CY. Analysis of Nosocomial Infections Caused by Bronchoscopy. Gansu Med J 2013;32(12):941-942.

[5] Shen C, Liang P, Che GW. Application and Research Progress of Video Double-lumen Tube in Thoracic Surgery. Chin J Lung Cancer 2022;25(08):622-626.

[6] Heir JS, Guo SL, Purugganan R, et al. A Randomized Controlled Study of the Use of Video Double-Lumen Endobronchial Tubes Versus Double-Lumen Endobronchial Tubes in Thoracic Surgery. J Cardiothorac Vasc Anesth 2018;32(1):267-274.

[7] Chen BL, Shi HW, Zhu JM. Application of fiberoptic bronchoscopy in the localization of double-lumen tube intubation. J Nanjing Med Univ (Nat Sci) 2007;(09):1062-1063.

[8] Hoogenboom EM, Ong C, Christodoulides G. Placement of VivaSight(TM) double lumen tube. Anaesthesia 2016;71(6):725-726.

[9] Zhao GQ. Comparison of the application effect of double-lumen tracheal catheter and bronchial occluder in thoracic surgery. China Pract Med 2024;19(03):45-48.

[10] Wang Y, Zhao WL. Progress in the application of lung isolation technique and double-lumen bronchial catheter. Pract Clin Med 2009;10(04):123-126.

[11] Sheng HB. Lung lobe auscultation in the application of double-lumen bronchial catheter. Chin Contemp Med 2011;18(28):70-71.

[12] Shang SM, Shi JY, Yang SS, et al. Analysis of Causes of Multidrug Resistance Bacteria Infection Caused by Fiberbronchoscope Contamination. J Pract Cardiovasc Pulm Vasc Dis 2021;29(10):113-116.

[13] Du SZ, Wang X, Ma HT, et al. Establishment of learning curve for visual dual-lumen bronchial catheter intubation in thoracoscopic surgery. Chin J Mod Med 2021;23(05):58-60.

[14] Wang HY, Bo LL. Application of visualization technology in the teaching of anesthesiology residency training. Health Career Educ 2022;40(16):138-141.

[15] Niu LJ, Rong J, Yang L, et al. Application of light wand in tracheal intubation teaching. China Med Educ Technol 2010;24(03):272-274.

[16] Zhou QL, Yang ZW, Xu F, et al. Application of Visual Teaching in the Teaching of Trunk Nerve Block for Resident Anesthesiologists. China Contin Med Educ 2023;15(14):189-193.

[17] Feng L, Tang YT, Dang L, et al. Study on the Application of Different Laryngoscope in Endotracheal Intubation Teaching for Nonanesthesia Specialty Physicians. China Contin Med Educ 2023;15(15):111-115.

[18] Zhou HO, Lei L, Qian XD, et al. Clinical application of the visual double-lumen bronchial tube in thoracic operation. Chin J Endosc 2018;24(12):72-76.

[19] Li HT, Xie HM, Zhang YQ. Effect of visual dual-lumen bronchial catheterization on the success rate and incidence of adverse events in patients undergoing single-lung ventilation surgery. China Med Device Inf 2023;29(21):107-109

[20] Zheng M, Liu YD, Wang T, et al. A Meta-analysis about the effect of visual double-lumen bronchial tube in thoracic surgery. Xinjiang Med 2021;51(12):1348-1352.

[21] Zhang ZX, Li MX. Determination of tracheal and bronchial radial values and their value by CT. J Clin Pulmonol 2004;(05):501-502.

[22] Wang JB, Zhang HQ, Zhang ZW, et al. The effect of CT Three-dimensional reconstruction technique in guiding difficult tracheal intubation with rigid fiber bronchoscope. Clin Misdiagn Mistreat 2019;32(08):55-59.

[23] Xiu PH. Clinical study on type of DLT selected by measurement of bronchial diameter on CT. China Clin Med 2005;(05):925-926.

[24] Guan HL, Hu XY. Establishment and varification of a prediction model for selecting double-lumen endobronchial tube type according to chest CT for thoracic surgery patients. J Qiqihar Med Coll 2023;44(17):1659-1664.

[25] Wang L, Li SP, Zhou LP, et al. The value of CT scanning in preoperative airway assessment. Hainan Med 2010;21(19):126-127.

[26] Huang XQ. Application of GlideScope visual laryngoscope combined with fiberoptic bronchoscope guidance in double-lumen bronchial intubation in patients with difficulties in vocal fold visualization. China Mod Drug Appl 2021;15(14):83-85.

[27] Gold JA, Hu X, Huang G, et al. Medical student depression and its correlates across three international medical schools. World J Psychiatry 2019;9(4):65-77.

[28] Liu YY, Huang ZX, Yu HY, et al. The Analysis of Status of Mental Stress Status of Students for Standardized Residency Training in the Prefecture City. Contin Med Educ 2022;36(04):33-36.