The Effects of Anesthesiologist Experience on Postoperative Hoarseness After Double-Lumen Endotracheal Tube Intubation: A Single-Center Propensity Score-Matched Analysis

Yuji Kamimura (ez4pixy1118@gmail.com)  
Nagoya Shiritsu Daigaku  https://orcid.org/0000-0002-0885-6343

Toshiyuki Nakanishi  
Nagoya Shiritsu Daigaku

Aiji Sato(Boku)  
Aichi Gakuin Daigaku

Satoshi Osaga  
Nagoya Shiritsu Daigaku

Eisuke Kako  
Nagoya Shiritsu Daigaku

Kazuya Sobue  
Nagoya Shiritsu Daigaku

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Abstract

**Background:** Postoperative hoarseness after general anesthesia is associated with patient discomfort and dissatisfaction. A recent large retrospective study showed that single-lumen endotracheal tube intubation by a trainee did not alter the incidence of postoperative pharyngeal symptoms compared with that by a senior anesthesiologist. However, little is known about the relationship between anesthesiologist experience and hoarseness after double-lumen endotracheal tube intubation. We tested the hypothesis that double-lumen endotracheal tube intubation by a trainee increases the incidence of postoperative hoarseness compared with that by a senior anesthesiologist.

**Methods:** This retrospective observational study included patients who underwent lung resection from April 2015 to March 2018 in a university hospital. Patients underwent double-lumen endotracheal tube intubation with a Macintosh laryngoscope. We divided the patients into two groups: one group comprising patients whose tracheas were intubated by a trainee anesthesiologist and the other comprising those whose tracheas were intubated by a senior anesthesiologist. The primary outcome was the incidence of postoperative hoarseness 24 h after surgery. We collected data on postoperative hoarseness using a checklist of postanesthetic adverse events. One-to-one propensity score matching was performed. P values of <0.05 were considered statistically significant.

**Results:** There were 256 eligible patients; 153 patients underwent intubation by trainee anesthesiologists, and the remaining 103 patients underwent intubation by senior anesthesiologists. The one-to-one propensity score matching generated 96 pairs of patients for the groups. The incidence of postoperative hoarseness 24 h after the surgery was significantly higher in patients whose tracheas were intubated by a trainee anesthesiologist than in those whose tracheas were intubated by a senior anesthesiologist (9.4% vs. 2.1%, respectively; P = 0.03).

**Conclusions:** Double-lumen endotracheal tube intubation by trainee anesthesiologists increased the incidence of postoperative hoarseness 24 h after the surgery compared with intubation by senior anesthesiologists.

**Background**

Postoperative hoarseness after general anesthesia is associated with patient discomfort and dissatisfaction. Several risk factors, such as patient demographic factors, quality of intubation, and perioperative management, have been reported to be associated with postoperative hoarseness [1, 2, 3].

In lung surgery, double-lumen endotracheal tube (DLT) intubation is considered the gold standard for lung isolation. A systematic review evaluating 307 patients from four studies showed that the use of DLTs was associated with a higher risk of postoperative hoarseness than the use of a combination of single-lumen endotracheal tubes (SLTs) and endobronchial blockers [4]. The reported incidence of postoperative hoarseness after the insertion of a DLT is 5–50% [4, 5, 6]. High frequencies of hoarseness may be due to the thickness of DLTs and the skills required during intubation.
A recent large retrospective study involving more than 20,000 patients showed that endotracheal intubation by a trainee did not increase postoperative throat symptoms compared to intubation by a senior anesthesiologist [7]. However, the report only included patients who underwent SLT intubation. Therefore, little is known about the relationship between anesthesiologist experience and hoarseness after DLT intubation.

In this study, we tested the hypothesis that DLT intubation by a trainee increases the incidence of postoperative hoarseness compared with DLT intubation by a senior anesthesiologist.

**Methods**

The protocol was approved by the Nagoya City University Graduate School of Medical Sciences and Nagoya City University Hospital Institutional Review Board (Nagoya, Japan, approval number: 60-18-0073). Per our institutional review board’s code of ethics, we used an opt-out method and posted a description of the research protocol on the website of the Nagoya City University Graduate School of Medical Sciences on July 30, 2018, and the patients could withdraw from the study.

**Data source and study population**

This retrospective observational study included patients who underwent lung resection from April 2015 to March 2018. We included patients who underwent DLT intubation with a Macintosh laryngoscope and a neuromuscular blocking drug, who were ≥15 years of age, and who had an American Society of Anesthesiologists physical status classification (ASA-PS) of 1 or 2. Patients with preoperative hoarseness, those whose tracheas were intubated with a video laryngoscope, those who required emergency surgery, and those with missing data were excluded from this study.

**Study variables**

The exposure of interest was DLT intubation performed by a trainee or senior anesthesiologist. We divided the patients into two groups: one group comprising patients whose tracheas were intubated by a trainee anesthesiologist and the other comprising those whose tracheas were intubated by a senior anesthesiologist. In Japan, anesthesiologists can be certified as a Japanese Society of Anesthesiologists Qualified Anesthesiologist after completing a 2-year training program. We, therefore, defined trainee anesthesiologists as anesthesiologists with less than two years of anesthesia experience and senior anesthesiologists as those with more than two years of anesthesia experience. These definitions were equivalent to those used in a previous study [7]. We collected the following clinical variables: age, sex, height, weight, body mass index (BMI), ASA-PS, duration of anesthesia, intraoperative fluid balance, DLT size, intubation depth, number of intubation attempts, intracuff pressure of the DLT, Mallampati score, and Cormack–Lehane grade.
**Outcome measures**

The primary outcome was the incidence of postoperative hoarseness 24 h after surgery. The investigator (YK), who did not perform DLT intubation or manage anesthesia, collected data on postoperative hoarseness using a checklist of postanesthetic adverse events from the electronic medical record. We defined postoperative hoarseness as a patient-assessed change in voice quality. We did not qualitatively or objectively evaluate postoperative hoarseness. We investigated whether the anesthesiologist who assessed postoperative hoarseness was the one who provided anesthesia for the patient and whether he or she was a trainee or senior anesthesiologist.

**Perioperative patient treatment**

There were no standardized methods of induction or maintenance of anesthesia. After the patient arrived to the operating room, electrocardiography, pulse oximetry, and invasive blood pressure monitoring were performed. Patients received a combination of general and epidural anesthesia. After placement of a thoracic epidural catheter, general anesthesia was induced with propofol (a bolus dose of 1–2 mg/kg or a target-controlled infusion at 3–3.5 μg/ml), fentanyl (1–4 μg/kg) and remifentanil (0–0.3 μg/kg/min). After bolus administration of rocuronium (0.6–1 mg/kg), the attending trainee or senior anesthesiologist performed DLT intubation with a Macintosh laryngoscope. The blade size (3 or 4) was chosen based on anesthesiologist preference and the patient’s physique. Portex® Blue Line® Endobronchial Tubes-left (Smiths Medical, Minneapolis, MN, USA) with a stylet were used for all procedures. A water-soluble lubricant without lidocaine was applied to the tube. We used a 37-Fr DLT for men and a 35-Fr DLT for women, but the tube size was determined by the attending anesthesiologist with consideration of the patient’s height [8]. The attending anesthesiologist guided the DLT into position via a flexible bronchoscope and assessed the tube after moving it to the lateral decubitus position. Anesthesia was maintained with 1%–2.5% sevoflurane or propofol (target-controlled infusion at 2–3.5 μg/mL). The Bispectral Index® value was kept between 40 and 60 throughout the procedure. Postoperatively, residual neuromuscular blockade was reversed with sugammadex (2–4 mg/kg), and the DLT was removed in the operating room.

**Statistical analysis**

For sample size calculation, we assumed that the incidence of postoperative hoarseness 24 h after surgery in patients who underwent intubation by a trainee or senior anesthesiologist would be 20% and 5%, respectively, based on previous reports [4,5,6]. Thus, 89 patients in each group were required to provide 80% power to detect a statistical difference between the groups using the Fisher’s exact test with a two-sided significance level of 5%.

We conducted propensity score analyses to account for differences in baseline characteristics between the two groups. The c-statistic for evaluating the goodness of fit was calculated. We performed one-to-
one propensity score matching by nearest neighbor matching without replacement. The caliper width was set to 25% of the standard deviation of the propensity scores. The confounding factors included in the propensity score model were as follows: age, sex, height, weight, BMI, ASA-PS, duration of anesthesia, intraoperative fluid balance, tube size, tube depth, number of intubation attempts, intracuff pressure, Mallampati score, and Cormack–Lehane grade. We assessed the differences between the two groups before and after propensity score matching with standardized differences. Standardized differences of <10% were considered negligible imbalances in the baseline characteristics between the two groups. We compared the incidence of hoarseness 24 h after surgery between the two groups using the Fisher’s exact test for before matching and the McNemar test for after matching. P values of <0.05 were considered statistically significant. All statistical analyses were conducted using the R software program (version 3.5.0, R Foundation for Statistical Computing, Vienna, Austria).

Results

A flow diagram for cohort identification is shown in Fig. 1. During the study period, we identified 413 lung cancer patients who underwent lung resection. Of these, 256 were included in the full study cohort based on the predetermined inclusion and exclusion criteria; these 256 patients included 153 patients whose tracheas were intubated by a trainee anesthesiologist and 103 patients whose tracheas were intubated by a senior anesthesiologist. Overall, 32 anesthesiologists (10 trainee anesthesiologists and 22 senior anesthesiologists) participated in this study. The median (interquartile range) length of experience was 1 year (1–2 years) for trainee anesthesiologists and 10 years (7–14 years) for senior anesthesiologists.

Table 1 shows the patient characteristics before propensity score matching between the two groups. Some characteristics, including age, weight, BMI, ASA-PS, intraoperative fluid balance, tube size, tube depth, intracuff pressure, Mallampati score, and Cormack–Lehane grade, had standardized differences of >10%. 
### Table 1
Clinical characteristics before propensity score matching.

|                                | Trainee | Senior | Standardized difference (%) |
|--------------------------------|---------|--------|-----------------------------|
| **n = 153**                    | n = 103 |        |                             |
| **Age (median [IQR]; years)**  | 69 [57, 75] | 68 [61, 75] | 15.5                        |
| **Sex male/female (%)**        | 90/63 (58.8/41.2) | 62/41 (60.2/39.8) | 2.8                         |
| **Height (median [IQR]; cm)**  | 161.4 [155.0, 168.4] | 162.2 [155.6, 168.0] | 0.6                         |
| **Weight (median [IQR]; kg)**  | 59.6 [52.6, 66.3] | 58.0 [50.7, 64.3] | 15                          |
| **BMI (median [IQR]; kg/m²)**  | 22.8 [20.5, 25.0] | 22.3 [20.1, 24.2] | 17.1                        |
| **ASA-PS (%)**                 |         |        | 23.3                        |
| 1                              | 27 (17.6) | 10 (9.7) |
| 2                              | 126 (82.4) | 93 (90.3) |
| **Duration of anesthesia (median [IQR]; h)** | 4.0 [3.1, 5.0] | 4.0 [2.9, 5.0] | 1.4 |
| **Intraoperative fluid balance (median [IQR]; ml)** | 1299 [995, 1733] | 1232 [926, 1630] | 14.8 |
| **Tube size (%)**              |         |        | 14.6                        |
| 32 Fr                          | 12 (7.8) | 6 (5.8)  |
| 35 Fr                          | 64 (41.8) | 45 (43.7) |
| 37 Fr                          | 69 (45.1) | 49 (47.6) |
| 39 Fr                          | 8 (5.2)  | 3 (2.9)  |
| **Tube depth (median [IQR]; cm)** | 28 [27, 30] | 29 [27, 30] | 15.8 |
| **Intubation attempts (%)**    |         |        | 4.1                         |
| 1                              | 147 (96.1) | 99 (96.1)  |
| 2                              | 5 (3.3)  | 3 (2.9)  |
| 3                              | 0 (0.0)  | 0 (0.0)  |
| 4                              | 1 (0.6)  | 1 (1.0)  |

Data are described as the frequency (%) or median [interquartile range, IQR].

BMI, body mass index; ASA-PS, American Society of Anesthesiologists physical status classification
Table 2 shows the patient characteristics after propensity score matching between the two groups. The established model for estimating propensity scores had a c-statistic of 0.635. A total of 96 patients in each group were matched by propensity score matching. The patient characteristics were well balanced between the two groups after matching.
Table 2
Clinical characteristics after propensity score matching.

| After propensity score matching | Trainee | Senior | Standardized difference (%) |
|---------------------------------|---------|--------|-----------------------------|
| n = 96                          | n = 96  |        |                             |
| Age (median [IQR]; years)       | 71 [63, 76] | 68 [61, 75] | 1.8                          |
| Sex male/female (%)             | 57/39 (59.4/40.6) | 56/40 (58.3/41.7) | 2.1                          |
| Height (median [IQR]; cm)       | 161.3 [154.6, 166.7] | 162.1 [154.7, 167.9] | 0.4                          |
| Weight (median [IQR]; kg)       | 57.5 [52.1, 61.97] | 58.3 [50.5, 64.2] | 5.8                          |
| BMI (median [IQR]; kg/m\(^2\))  | 22.1 [20.1, 24.1] | 22.4 [20.1, 24.3] | 7.1                          |
| ASA-PS (%)                      | 3.3     |        |                             |
| 1                               | 11 (11.5) | 10 (10.4) |                             |
| 2                               | 85 (88.5) | 86 (89.6) |                             |
| Duration of anesthesia (median [IQR]; h) | 3.88 [2.75, 4.86] | 3.95 [2.96, 5.04] | 1.9                          |
| Intraoperative fluid balance (median [IQR]; ml) | 1222 [931, 1518] | 1224 [926, 1630] | 3.1                          |
| Tube size (%)                   | 7.8     |        |                             |
| 32 Fr                           | 5 (5.2) | 6 (6.2) |                             |
| 35 Fr                           | 43 (44.8) | 43 (44.8) |                             |
| 37 Fr                           | 45 (46.9) | 45 (46.9) |                             |
| 39 Fr                           | 3 (3.1) | 2 (2.1) |                             |
| Tube depth (median [IQR]; cm)   | 28 [27, 30] | 28 [27, 30] | 4.6                          |
| Intubation attempts (%)         | 14.5    |        |                             |
| 1                               | 93 (96.9) | 92 (95.8) |                             |
| 2                               | 3 (3.1) | 3 (3.1) |                             |
| 3                               | 0 (0.0) | 0 (0.0) |                             |
| 4                               | 0 (0.0) | 1 (1.0) |                             |

Data are described as the frequency (%) or median [interquartile range, IQR].

BMI, body mass index; ASA-PS, American Society of Anesthesiologists physical status classification.
### After propensity score matching

| Outcome                  | Trainee Median [IQR; cmH\(_2\)O] | Senior Median [IQR; cmH\(_2\)O] | P  |
|--------------------------|----------------------------------|---------------------------------|----|
| Cuff pressure            | 20 [20, 22]                      | 20 [20, 20]                     | 6.5|
| Mallampati score (%)     | 74 (77.1)                        | 75 (78.1)                       | 2.5|
| 1                        | 22 (22.9)                        | 21 (21.9)                       |    |
| 2                        | 0 (0.0)                          | 0 (0.0)                         |    |
| 3                        | 0 (0.0)                          | 0 (0.0)                         |    |
| 4                        | 0 (0.0)                          | 0 (0.0)                         |    |
| Cormack–Lehane grade (%) | 76 (79.2)                        | 76 (79.2)                       | < 0.1|
| 1                        | 20 (20.8)                        | 20 (20.8)                       |    |
| 2                        | 0 (0.0)                          | 0 (0.0)                         |    |
| 3                        | 0 (0.0)                          | 0 (0.0)                         |    |
| 4                        | 0 (0.0)                          | 0 (0.0)                         |    |

Data are described as the frequency (%) or median [interquartile range, IQR].

BMI, body mass index; ASA-PS, American Society of Anesthesiologists physical status classification

The incidence of postoperative hoarseness 24 h after surgery was significantly higher for intubation by trainee anesthesiologists than for intubation by senior anesthesiologists (9.4% vs. 2.1%, P = 0.03; Table 3). Postoperative hoarseness was assessed by the anesthesia provider in 85% of trainee intubations and 80% of senior anesthesiologist intubations.

### Table 3

| Outcome     | Full cohort | Propensity score-matched cohort |
|-------------|-------------|---------------------------------|
|             | Trainee     | Senior                          | Trainee | Senior |
| Hoarseness  | 18 (11.8)   | 2 (1.9)                         | 9 (9.4) | 2 (2.1) | 0.03 |

Data are described as the frequency (%).

### Discussion

The patients who underwent DLT intubation by trainee anesthesiologists had a higher incidence of postoperative hoarseness than those who underwent DLT intubation by senior anesthesiologists in lung
surgery. This result indicates that lack of experience could be a risk factor for postoperative hoarseness in patients undergoing DLT intubation.

The increased incidence of postoperative hoarseness observed in our patients whose tracheas were intubated by a trainee anesthesiologist differed from the results of a previous study using SLTs [7]. One possible explanation for this difference may be that DLT intubation requires more technical skills than SLT intubation for the following reasons. First, a DLT has a solid curved body, which can easily come into contact with the vocal cords [9]. Second, the incidence of postoperative hoarseness was reported to directly correlate with the size of the endotracheal tube [3]. The thicker diameter of DLTs may have made it difficult for trainee anesthesiologists to pass through the glottis.

The incidence of postoperative hoarseness 24 h after surgery was lower in both groups in the present study (9.4% for trainee anesthesiologists and 2.1% for senior anesthesiologists) than that in previous studies (5–50%) [4, 5, 6]. Only patients who subjectively complained were considered to have postoperative hoarseness, so the incidence of postoperative hoarseness may have been underestimated. Thus, it is not easy to compare the results of this study with those of previous studies because of the different definitions of hoarseness. Since postoperative hoarseness is a subjective patient complaint, it is essential to know the comfort level of the patient. Therefore, we believe that the outcome evaluated in our study is clinically meaningful. A validated outcome measure, such as the voice handicap index [10], may be a more reliable assessment in future studies.

We acknowledge that the present study had some limitations. First, it was a single-center, retrospective observational study with a relatively small sample size. Prospective randomized controlled trials are required to validate our results in the future. Second, a considerable number of patients were excluded from this study, which may have caused selection bias. Third, 80–85% of the evaluators were anesthesia providers, which may have caused observer bias and ascertainment bias. However, this study has the advantage that neither the evaluators nor the patients were aware of the study's purpose due to the study's retrospective nature. Therefore, evaluator influence on the results of this study, which were analyzed in real-world clinical practice, is likely minimal. Finally, although we attempted to limit selection bias using propensity score matching, the multifactorial etiologies of postoperative hoarseness that affect the outcomes may not have been removed.

**Conclusions**

DLT intubation by trainee anesthesiologists increased the incidence of postoperative hoarseness 24 h after surgery compared with DLT intubation by senior anesthesiologists.

**Abbreviations**

ASA-PS
American Society of Anesthesiologists physical status classification
Declarations

Ethics approval and consent to participate

The protocol was approved by the Nagoya City University Graduate School of Medical Sciences and Nagoya City University Hospital Institutional Review Board (Nagoya, Japan, approval number: 60-18-0073). Per our institutional review board’s code of ethics, we used an opt-out method and posted a description of the research protocol on the website of the Nagoya City University Graduate School of Medical Sciences on July 30, 2018, and the patients could withdraw from the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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No funding was obtained for this study.

Authors’ contributions

YK wrote this manuscript under the supervision of TN, AS, EK and KS. YK and SO designed the study and analyzed the data. TN, AS and EK made substantial contribution to the interpretation of the data. All authors have read and approved the final version of the manuscript.
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Not applicable.

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Figures
Figure 1

Study flow diagram The values indicate the number of all eligible patients during the study period. ASA-PS, American Society of Anesthesiologists physical status classification; PS, propensity score