

# Effects of bevel direction of endotracheal tube on the postoperative sore throat when performing fiberoptic-guided tracheal intubation

## A randomized controlled trial

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### Abstract

**Background:** During fiberoptic-guided tracheal intubation, impingement between the distal tip of the endotracheal tube and the airway tissue can cause difficulties in tube insertion or tissue damage during the tube advancement over the bronchoscope. This randomized controlled study aimed to investigate the effects of the endotracheal tube's bevel direction on the complications associated with airway injury when performing fiberoptic-guided tracheal intubation.

**Methods:** The study subjects were divided into 2 groups: L (control) and D (study). When advancing the tube over the bronchoscope, the tube's bevel was facing the patients' left in Group L and the dorsal direction in Group D. According to the degree of resistance at the time of tube advancement, the insertion score was graded in 3 stages; the severity of the patients' sore throat and hoarseness was evaluated and recorded postoperatively.

**Results:** The severity of postoperative sore throat was higher in Group L than in Group D 3 hours and 24 hours after surgery. ( $P = .008$ ,  $P = .023$ , respectively). The tube insertion score was comparable between the groups. The severity of postoperative hoarseness did not vary significantly between the groups.

**Conclusion:** Endotracheal tube insertion with the bevel facing the dorsal direction of the patient during fiberoptic-guided tracheal intubation reduced the severity of postoperative sore throat in patients undergoing laparoscopic gynecologic surgery.

**Abbreviations:** BIS = bispectral index, IV-PCA = intravenous patient controlled analgesia, NRS = numerical rating scale, TOF = train-of-four, VAS = visual analog scale.

**Keywords:** anesthesia, bronchoscopy, intubation, sore throat

## 1. Introduction

In case of anatomical concerns such as tooth damage, endotracheal intubation under fiberoptic bronchoscopy guidance can be applied. After confirming that the fiberoptic bronchoscope has passed through the glottis and entered the trachea, the endotracheal tube is advanced over the bronchoscope to perform tracheal intubation. During the procedure, trauma to the airway tissues may occur when the endotracheal tube approaches the glottis owing to the gap in the diameter between the bronchoscope and the endotracheal tube.<sup>[1]</sup> This can cause sore throat and hoarseness after the surgery. Evidence suggests that 5% to 16% of moderate to severe cases of sore throat occur after fiberoptic-guided tracheal intubation.<sup>[2]</sup>

Despite the bronchoscope being already mounted in the trachea, advancing the endotracheal tube over the fiberoptic bronchoscope may not be feasible during fiberoptic-guided tracheal

intubation as the distal tip of endotracheal tube can be caught on periglottic structures<sup>[3,4]</sup> such as epiglottis, arytenoid cartilage, cuneiform cartilage, corniculate cartilage, or interarytenoid notch. The methods to facilitate tube advancement include using a smaller diameter tube to reduce the gap between the tube and the bronchoscope,<sup>[5]</sup> using a specially designed endotracheal tube,<sup>[6]</sup> using the endotracheal tube after heating and softening it,<sup>[7]</sup> and reinserting the tube through a 90° counterclockwise rotation.<sup>[4,5]</sup> Among them, the reason for rotating the tube 90° counterclockwise is to direct the tube bevel toward the patient's dorsal direction to prevent the distal tip of the tube from colliding around the glottic tissue. Thus, the present study was based on the hypothesis that endotracheal tube insertion over the bronchoscope with the tube's bevel facing the patient's dorsal direction would facilitate tube advancement and reduce postoperative sore throat. This study aimed to investigate a

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

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method with less impingement between the endotracheal tube and the airway tissue that will also be convenient for clinical use when inserting an endotracheal tube under fiberoptic bronchoscope guidance.

## 2. Materials and methods

### 2.1. Study design

The present study was approved by the Institutional Review Board of Kyungpook National University Hospital (KNUH 2020-10-025; December 3, 2020) and registered on [cris.nih.go.kr](http://cris.nih.go.kr) (KCT0005677) prior to enrollment. This study was designed as a prospective, randomized, controlled trial and was conducted at the Kyungpook National University Hospital. Patients scheduled for surgeries under general anesthesia were enrolled, and they provided written informed consent for participation.

### 2.2. Inclusion/exclusion criteria

The study inclusion criteria were as follows: patients were undergoing laparoscopic gynecological surgery under general anesthesia, were aged 18 to 65 years, were expected to undergo surgery and anesthesia duration of  $\leq 3$  hours, and had an American Society of Anesthesiologists physical status class of I–II. Those who were severely obese (body mass index  $\geq 30$  kg/m<sup>2</sup>),<sup>[5]</sup> had a thyromental distance of  $< 6.5$  cm, were Mallampati class III or IV, had a history of recent upper respiratory infection or sore throat within 7 days before surgery, were taking steroid medications, and were pregnant were excluded from the study. Furthermore, patients for whom  $>1$  attempt was required to insert the bronchoscope into the trachea as well as those who had an anesthesia duration of  $< 1$  h or  $> 3$  hours, experienced events of airway spasm or bucking during surgery and extubation, changed head and neck position during surgery (e.g., rotation, flexion, and extension), vomited during the study period, stopped using intravenous patient-controlled analgesia (IV-PCA) for any reason, or received analgesics other than IV-PCA were excluded from the subsequent analyses.

### 2.3. Randomization and blinding

The patients were categorized into 2 groups: Group L (tube bevel facing the patient's left; control group) and Group D (bevel facing the patient's dorsal direction). A randomization sequence for the 2 groups in a 1:1 ratio was generated in blocks of 8 using a computer-generated random number sequence. Using sealed, number-coded envelopes, group allocation was performed by the research assistant not involved in data collection and analysis the day before the surgery. The distribution results were known to the investigator in charge of the bevel direction, but not to the patients and investigators responsible for data collection and analysis throughout the study.

### 2.4. Study procedures

No premedication drugs were used. Upon the patients' arrival in the operation room, their electrocardiograph, noninvasive blood pressure, pulse oximetry, temperature, and bispectral index (BIS) were monitored. Vital signs were recorded at 5-minute intervals in the operating room and postanesthesia care unit. To induce general anesthesia, intravenous propofol 1.5 to 2 mg/kg, target-controlled intravenous infusion of remifentanyl (3.5–4.5 ng/mL), and intravenous rocuronium 0.6 mg/kg were administered in all patients. After the reduction of BIS  $< 50$  and abolition of train-of-four (TOF) response (TOF 0), an investigator blinded to the group allocation performed fiberoptic-guided tracheal intubation. The Shiley™ Lo-Contour

flexible reinforced endotracheal tube (Covidien Ireland Limited, Tullamore, Ireland), with an outer diameter of 7.0 mm, was used for tracheal intubation. The endotracheal tube was premounted near the proximal site of the bronchoscope (Olympus LF-GP, Olympus Optical Co., Tokyo, Japan), and the bronchoscope was inserted into the trachea through the patient's mouth while an assistant was pulling the patient's jaw.

When it was confirmed that the bronchoscope had entered the trachea, another investigator adjusted the bevel direction of endotracheal tube to the allocated group, and advanced the tube to the depth where the tube balloon would go into the patient's mouth. The bronchoscopy operator then took over the endotracheal tube and advanced it into the trachea while looking at the bronchoscope screen, and ranked the score in 3 stages according to the degree of resistance during tube insertion and recorded it on the case record sheet. During the tube insertion, the investigator in charge of the bevel direction monitored the tube to prevent rotation.

The maintenance of and recovery from anesthesia was performed by medical staff who did not participate in the study. During the surgery, anesthesia was maintained using sevoflurane, target-controlled intravenous infusion of remifentanyl (2.5–3.5 ng/mL), and intravenous rocuronium for neuromuscular blockade. The BIS was maintained at 40 to 55, and the TOF response was monitored. The cuff pressure was adjusted between 20 and 25 cm H<sub>2</sub>O using a manual cuff pressure manometer (Cuff Manometer, Mallinckrodt Medical, Athlone, Ireland).<sup>[8]</sup> All patients received IV-PCA (a total of 100 mL of fentanyl 600  $\mu$ g and ketorolac 240 mg in normal saline) with a basal infusion rate of 2 mL/h, on-demand 1-mL boluses, and a lockout interval of 10 minutes. The continuous intravenous administration of remifentanyl was discontinued 5 minutes before the end of the surgery, and IV-PCA was infused. After the end of the surgery, intravenous sugammadex was administered, and manual ventilation was performed. When adequate spontaneous respiration was recovered with a TOF value  $> 0.9$ , the endotracheal tube was extubated. After cessation of sevoflurane, breathing was assisted by jaw thrust or bag mask ventilation if necessary until the patients opened their eyes on demand.

An investigator who was blinded to group allocation evaluated postoperative sore throat and hoarseness after 3 and 24 hours of the surgery.

### 2.5. Study assessments

The primary outcome was the difference in the postoperative sore throat scores between the groups, and the secondary outcome was the difference in the tube insertion score and the score of postoperative hoarseness.

The degree of resistance during the tube insertion was divided into 3 grades by the bronchoscopy operator (insertion score: 0 = no resistance when entering the tube, 1 = mild resistance but entry is possible, 2 = moderate resistance but entry is possible, and 3 = insertion of the endotracheal tube failed because of severe resistance, the tube was retracted and then rotated for insertion).

To evaluate postoperative sore throat at 3 and 24 hours after the surgery, a visual analog scale (0–100 mm, where a score of 0 denotes no throat pain and a score of 100 means the worst throat pain imaginable) was used by a designated investigator (K.J.E.) who was blinded to the allocated groups. Postoperative hoarseness was evaluated using a numerical rating scale (0 = no hoarseness, 1 = felt only by the patient, 2 = evident to the evaluator, and 3 = difficult to vocalize).

The total usage of analgesics through IV-PCA or other approaches was recorded. Airway-associated postoperative discomforts other than sore throat and hoarseness, such as cough, were also investigated and recorded.

**2.6. Statistical analyses**

Statistical analyses were performed using SPSS version 24.0 (IBM Corporation, Armonk, NY). The sample size was calculated from a pilot study in which the severity of sore throat 3 hours after the surgery (mean ± standard deviation) was 14.9 ± 13.2 and 7.2 ± 9.4 in Groups L and D, respectively (n = 11 per group). Assuming a 2-tailed α of 0.05 and a power of 80%, the required sample size was determined to be 76 (38 per group) to assess the severity of sore throat 3 hours after the surgery in order to demonstrate a statistically significant difference between the 2 groups. Thus, assuming possible dropouts, a target sample size of 43 patients per group was planned. None of the patients in the pilot study were included in this study.

Descriptive statistics were used to present the demographic data and target measurements. Continuous variables are presented as the mean and standard deviation. The scores of hoarseness are presented as frequency. To compare continuous variables, the independent Student *t* test was performed according to the characteristics and distribution of the data. Levene test was used to assess the homogeneity of variances. The scores of insertion, sore throat, and hoarseness were compared using the Mann–Whitney *U* test. *P* < .05 was considered significant.

**3. Results**

In total, 86 patients were enrolled from a total of 127 patients assessed for their eligibility to be included in this study. A total of 27 patients were excluded based on the inclusion/exclusion criteria, and 14 declined to participate. Seven patients were not included in the analysis because a failure at the first attempt to insert the bronchoscope into their trachea, the duration of their surgery, bucking before extubation, no use of IV-PCA, and the use of analgesics other than IV-PCA. Thus,

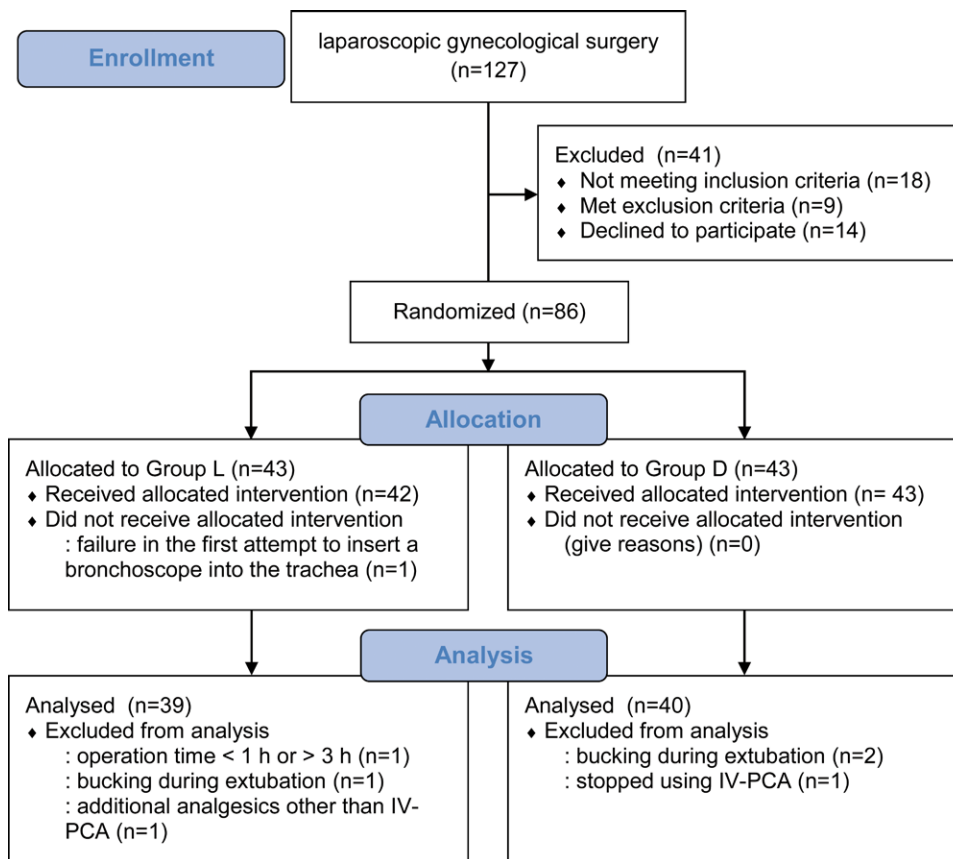
a total of 79 patients were included in the analysis (Group R, 39; Group A, 40; Fig. 1). The surgeries performed were ovarian cystectomy, salpingo-oophorectomy, and myomectomy. Recruitment took place between January 5, 2021, and October 15, 2021.

Demographic data of the patients and procedure durations are presented in Table 1. The patients' age, height, weight, anesthesia duration, and total IV-PCA consumption till 24 hours postsurgery did not vary significantly between the groups.

The severity of postoperative sore throat was higher in Group L than in Group D after surgery (3 hours, *P* = .008, effect size = 0.30; 24 hours, *P* = .023, effect size = 0.25; Table 2). The insertion score-related resistance during the endotracheal tube advancement over the bronchoscope was comparable between the groups. The severity of postoperative hoarseness did not vary significantly between the groups.

**4. Discussion**

This study demonstrated that during fiberoptic-guided tracheal intubation, the severity of postoperative sore throat was reduced when the endotracheal tube was inserted with the tube's bevel facing the patient's dorsal direction. The resistance felt during the endotracheal tube advancement over the bronchoscope was similar between the control group with the tube bevel facing left and the study group with the tube bevel facing the dorsal direction. Despite the reduced sore throat, no difference was detected in the resistance during tube advancement, probably because the overall score of the insertion resistance was low; this thus indicated no statistical difference. In addition, there was no meaningful difference in comparing the postoperative hoarseness because the incidence of hoarseness was low in all of study subjects.



**Figure 1.** Patients' flow diagram. IV-PCA = intravenous patient controlled analgesia.

**Table 1**  
Demographic data, the duration of surgery and anesthesia, and the total consumption of IV-PCA until 24 hr after surgery.

	Group L (n = 39)	Group D (n = 40)	P value
Age (yr)	50 ± 9.7	49 ± 10.4	.41
Height (cm)	162 ± 5.1	162 ± 5.3	.76
Weight (kg)	60 ± 5.3	60 ± 4.4	.86
Surgery time (min)	122 ± 24.0	115 ± 26.5	.24
Anesthesia time (min)	127 ± 24.0	121 ± 25.8	.29
IV-PCA (mL) (24 hr)	58 ± 6.2	56 ± 5.9	.26

Values are mean ± SD.

IV-PCA = intravenous patient controlled analgesia, SD = standard deviation.

**Table 2**  
Insertion score for endotracheal tube advancement as well as the score of the postoperative sore throat and hoarseness.

	Group L (n = 39)	Group D (n = 40)	P value
Insertion score (0/1/2/3)	23/13/3/0	27/12/1/0	.37
3-hr sore throat severity (VAS, 0–100)	13.9 ± 11.3	7.3 ± 8.4	.008
24-hr sore throat severity (VAS, 0–100)	10.1 ± 9.2	6.0 ± 7.5	.023
3-hr hoarseness severity (0/1/2/3)	37/2/0/0	39/1/0/0	.54
24-hr hoarseness severity (0/1/2/3)	37/2/0/0	39/1/0/0	.54

Values are mean ± SD or number of patients.

SD = standard deviation, VAS = visual analog scale.

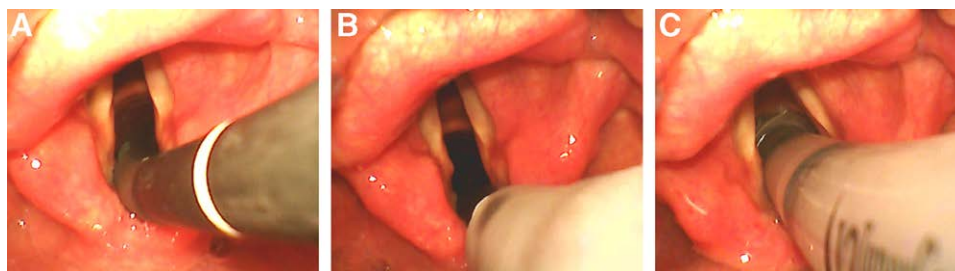
Postoperative sore throat includes a variety of symptoms such as pharyngitis, laryngitis, tracheitis, and hoarseness.<sup>[9]</sup> The causes of postoperative sore throat include tissue injury due to the blade of the direct laryngoscope during tracheal intubation, trauma caused by the endotracheal tube during the tracheal intubation or extubation, excessive pressure due to the endotracheal tube cuff during surgery, the movement of the head or neck during surgery, and coughing/bucking during anesthesia.<sup>[9–11]</sup> The longer surgery time has been reported as a risk factor of postoperative sore throat.<sup>[12]</sup> Several studies have explored the occurrence of postoperative sore throat associated with the difference in endotracheal tube size, which consistently revealed that the smaller the diameter of the tube, the lower the incidence of sore throat.<sup>[9,10,13]</sup> This suggests that pressure at the tube–mucosal interface and tissue damage due to the larger diameter tube may affect postoperative sore throat.

A study performing nasotracheal intubation reported that the incidence of postoperative sore throat was significantly

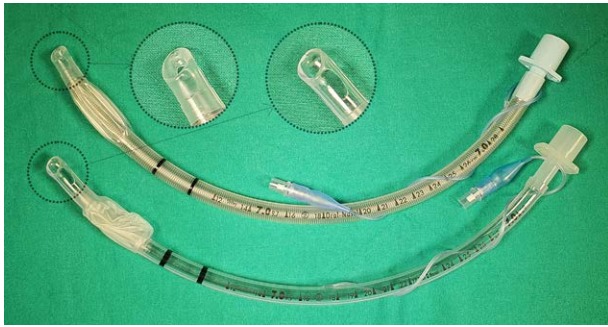
reduced after using a fiberoptic bronchoscope (6/37, 16.2%) compared with a direct Macintosh laryngoscope (17/37, 46.0%).<sup>[14]</sup> The primary cause to reduce postoperative sore throat could be the avoidance of tissue injury by the blade of the laryngoscope. However, the fiberoptic-guided tracheal intubation could not completely eliminate sore throat. In contrast to the direct laryngoscope procedure, during which the operator inserts the endotracheal tube while looking directly at the glottis and tube, in fiberoptic-guided tracheal intubation, the operator cannot directly see the process of the tube advancement through the glottis. Instead, the operator only pushes the endotracheal tube along with the preinserted bronchoscope. When the endotracheal tube passes the glottis, it can scratch or rub the surrounding tissue<sup>[1]</sup> (Fig. 2). At this time, the larger the gap in the diameter between the bronchoscope and the endotracheal tube, the greater the degree to which the tube hits the periglottic structures, making it difficult to proceed.<sup>[5,6]</sup> Using a smaller diameter tube, which is a method to facilitate tube advancement, is also aimed at reducing the gap between the tube and bronchoscope. In this study, an endotracheal tube with an outer diameter of 7.0 mm and a bronchoscope with an outer diameter of 3.8 mm were used in all study subjects to exclude confounding variables from the gap difference.

General endotracheal tubes have their own curvature; therefore, when the tube is advanced over the bronchoscope, the tube's bevel faces the patient's left and the distal tip faces the patient's right in many cases<sup>[15]</sup> (Fig. 3). Figure 2 shows the bronchoscope mounted in contact with the dorsal side of the glottis. If the tube is rotated 90° counterclockwise, its tip is positioned ventral to the glottis instead of the right of the glottis, thus allowing it to enter with the least impingement against the tissue. In the present study, it can be inferred that insertion with the bevel of endotracheal tube facing the patient's dorsal direction might have reduced tissue injury and thus reduced postoperative sore throat.

Owing to the own curvature of the endotracheal tube itself, special attention must be paid to controlling the bevel direction when advancing the tube over the bronchoscope. The endotracheal tube used in this study was an armored tube with high flexibility. However, in the case of a general endotracheal tube, when its bevel direction shifts to the patient's dorsal direction, the entire curvature of the tube changes to a convex forward. Therefore, it may be challenging to advance the tube in such a scenario, depending on the experience of the operator. Thus, when using a general endotracheal tube, it is recommended to turn the direction of the bevel after the tip of the tube has passed the tongue base. In addition, because the shape and material of the distal tip of the endotracheal tube differ depending on the type, the degree of tube insertion resistance and the result of postoperative sore throat may be different from the result of this study when a general tube other than an armored tube is used.



**Figure 2.** Impingement between the endotracheal tube and airway tissue during fiberoptic-guided tracheal intubation. (A) The bronchoscope is passed through the glottis during jaw thrust. Note that the bronchoscope is located closely to the patient's dorsal side of the glottis. (B) The endotracheal tube approaches the glottis over a bronchoscope. Note the impingement between the distal tip of the tube and the dorsal structure of the glottis. (C) The endotracheal tube is passed through the glottis.



**Figure 3.** Endotracheal tubes with their curvature. When the endotracheal tube is advanced over the bronchoscope, it is naturally positioned in forward concave flexion, with the bevel of the tube to the left and the distal tip of the tube to the right.

#### 4.1. Limitations

The present study has some limitations. First, patients with anticipated difficulty in tracheal intubation were excluded from the study. Since fiberoptic-guided tracheal intubation is mainly used when difficulty in tracheal intubation is expected, a wide spectrum of subjects is needed in the future for the clinical application of the results of this study. Second, the study cohort comprised only women. To target a similar surgical position, surgical environment, and duration, laparoscopic gynecological surgery patients were selected, which limited the interpretation and broad application of the study results. Further studies involving a broader patient population are needed. Third, we only used an armored endotracheal tube in this study. Based on the type of the tube, differences in the shape, surface material, and elasticity of the distal tip of the tube may exist, and the effect on the resistance or impingement that occurs during tube advancement should be considered. Fourth, blood pressure and heart rate during endotracheal intubation were not investigated separately. Although the procedure was performed focusing on the BIS and TOF values, if the data regarding blood pressure and heart rate were included, meaningful interpretations associated with pain during endotracheal intubation could be derived further. Finally, the occurrence of cough after surgery was not evaluated. Because sore throat and cough associated with endotracheal intubation can be mutually causative and exacerbate each other; further investigation should be performed in future studies.

#### 5. Conclusions

During fiberoptic-guided tracheal intubation in laparoscopic gynecologic surgery, endotracheal tube insertion over bronchoscope with the bevel facing the patient's dorsal direction reduces the severity of postoperative sore throat. Since this study was limited to female patients and did not include those who were expected to present difficult airways, a study with a broad spectrum of subjects is needed in the future for the clinical application of the results. In addition, further studies are warranted to identify a method for mitigating the postoperative sore throat after fiberoptic-guided tracheal intubation.

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#### Author contributions

Conceptualization: Hyunjee Kim.  
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