



CLINICAL RESEARCH

Evaluation of lightwand-guided endotracheal intubation for patients with missing or no teeth: a randomized controlled study

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KEYWORDS

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Abstract

Background: Unhealthy teeth can seriously affect general health and increase the risk of death in elderly people. There has been no confirmation of which device is most effective for elderly patients with teeth loss. Therefore, we compared four intubation devices in elderly patients with partial and total tooth loss aiming to reduce risk during anesthesia.

Methods: Two hundred patients were randomized to undergo tracheal intubation with the Macintosh laryngoscope, the Glidescope, the Fiberoptic bronchoscope or the Lightwand as part of general anesthesia. A unified protocol of anesthetic medications was used. HR and BP were measured at T₀, T₁, T₂, T₃, T₄ and T₅. Catecholamine (epinephrine and norepinephrine) blood samples were drawn at T₀, T₁ and T₂. Intubation time and postoperative complications, including dental damage and losses, were recorded.

Results: Reduced fluctuations in HR, DBP, and SBP were observed in the Lightwand group. Intubation time was significantly shorter in the Lightwand group ($p < 0.05$). There was no statistically significant difference between the groups in epinephrine levels, but norepinephrine levels were less volatile in the Fiberoptic bronchoscope and Lightwand groups. Fewer patients in the Lightwand group experienced dental damage and other postoperative complications than in the other three groups. Although a higher success rate on the first attempt was as high as in the Fiberoptic bronchoscope group, shorter intubation time was observed only in the Lightwand group.

Conclusion: The Lightwand offers less hemodynamic stimulation than the Macintosh laryngoscope, Glidescope, and Fiberoptic bronchoscope. Because it had the shortest intubation time, the Lightwand caused the least damage to the teeth and throat of elderly patients. Our findings showed that tracheal intubation with the Lightwand was advantageous for preventing cardiovascular stress responses with short intubation times and fewer postoperative complications.

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Introduction

As the aging of society intensifies, more elderly patients with multisystem complications will require general tracheal intubation anesthesia for surgery.¹ However, following laryngoscopy and endotracheal intubation, undesired pathophysiological effects and postoperative complications frequently occur.^{2,3} Although healthy and young patients generally tolerate these responses well, elderly patients can experience worse outcomes.⁴ Dental injury, including fracturing or dislocating of teeth, is known to be a common feature of claims in anesthetic practice.⁵⁻⁷ Many studies have demonstrated that poor dental health is associated with mental impairment, physical disability, rheumatoid arthritis, and even increased mortality among elderly people.⁸⁻¹² Moreover, endotracheal intubation leads to a reflexive increase in sympathetic activity, including arrhythmia, hypertension, and tachycardia.¹³⁻¹⁵ Additionally, changes in plasma catecholamine concentrations have been reported from the stress of endotracheal intubation.^{4,16,17} Therefore, reducing dental damage and stress responses during surgery are important for elderly patients' postoperative health.

The risks of anesthesia and mortality for patients could be significantly increased by traditional laryngoscopy.^{18,19} Thus, alternative devices are used to facilitate laryngoscopy and improve the glottic view to reduce postoperative complications and mortality.²⁰ The Glidescope has a digital camera at its tip, which can improve the view of the glottis and is beneficial in patients with difficult airways.²¹ The Fiberoptic bronchoscope has a small, soft and bendable lumen for guidance and clear vision. Fiberoptic bronchoscope-guided intubation can be performed without stimulation of oropharyngeal structures.²² The Lightwand is a stick featuring a light bulb at its tip that can be used to perform tracheal intubation blindly after confirmation that the bulb has passed the glottis and is illuminating the anterior neck clearly.²³

Although Fiberoptic bronchoscopy or video laryngoscopes are used more commonly in patients with difficult laryngoscopic intubation,²⁴ the Lightwand can be used as a multimodal approach to difficult intubation. However, no studies have compared the effects of using different intubation equipment on elderly patients. The purpose of this study was to evaluate whether Lightwand-guided tracheal intubation was more suitable for elderly patients than other endotracheal intubation equipment.

Materials and methods

After approval from the institutional ethics committee, written informed consent was obtained from all patients before participating in the study. Two hundred patients were enrolled (aged 64–82 years old) with American Society of Anesthesiologists (ASA) I–II physical status requiring general anesthesia with endotracheal intubation undergoing surgery. Patients were excluded if they were at risk for regurgitation and aspiration or lacked informed consent. Patients with Mallampati scores of 3 or those with congenital or acquired abnormalities of the upper airway were also excluded.

All study subjects were randomized by a researcher blinded to the study, and envelopes containing randomization numbers were used to allocate the patients to the following four groups (n = 50 per group) according to the airway device used: group M (intubation attempt using a Macintosh laryngoscope), group G (intubation attempt using a Glidescope), group F (intubation attempt using a Fiberoptic bronchoscope), and group L (intubation attempt using a Lightwand). In all cases, intubation was performed by several experienced anesthesiologists who were familiar and trained (performed at least 30 intubations prior to the study) with all four devices. In the operating room, the patients were monitored using electrocardiography, noninvasive and invasive arterial blood pressure, oxygen saturation, and end-tidal carbon dioxide concentration.

For the four groups of patients, the tube size was chosen based on the manufacturers' recommendations. The endotracheal tube size for female and male patients was 7.0 and 7.5 mm, respectively. The laryngoscope blades used for female and male patients were sizes 3 and 4, respectively. The Lightwand was bent 6.5 cm from the distal end at a 90° angle similar to a hockey stick.

The patients underwent preanesthetic oxygenation by mask before standardized general anesthesia induction (0.4 µg.kg⁻¹ sufentanil, 0.05 mg.mL⁻¹ midazolam, 0.2 mg.kg⁻¹ etomidate followed by 0.6 mg.kg⁻¹ rocuronium) and 3-minute mask ventilation with 100% oxygen. After adequate neuromuscular blockade (TOF = 0) was confirmed, we checked the laryngeal view and the Modified Cormack and Lehane grade of the patients. The depth of sedation was monitored by Narcotrend (MonitorTechnik, Bad Bramstedt, Germany), and intubation was prepared when the Narcotrend index was 45–55.

In group M, the endotracheal tube was inserted and advanced blindly into the nasal cavity and passed into the pharynx. In group F, the Fiberoptic bronchoscope (Olympus LF-DP; Olympus, Tokyo, Japan) was inserted via the nasal cavity, and its passage past the intranasal structures and through the nasopharynx, oropharynx, larynx, and carina was observed with a jaw lift by the caregiver through the eyepiece of the scope. In group G, the Glidescope (Glidescope videolaryngoscopy, Verathon, Bothell, WA, USA) was inserted along the middle of the tongue and positioned at the epiglottis vallecula. Intubation was then performed with a stylet-inserted tracheal tube using the lift blade and confirmation of the glottis on the monitor. In group L, the tip of the Lightwand (Surch-Lite™ Orotracheal Lighted Intubation Stylet, Bovie, Melville, NY, USA) was bent similar to a hockey stick before the jaw lift. Up to 3 attempts were allowed before tracheal intubation was performed. Insertion time was defined as the time elapsed from opening the mouth until the first appearance of a square waveform on the capnograph.

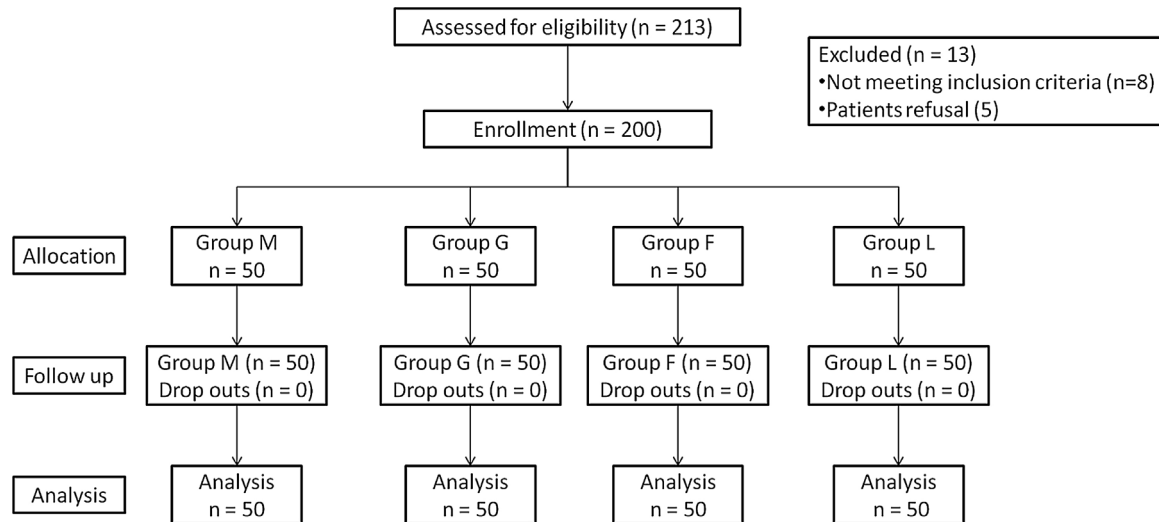
Hemodynamic measurement

Heart Rate (HR), Blood Pressure (BP), and Oxygen Saturation (SpO₂) were recorded preinduction (T₀), preintubation (T₁), immediately postintubation (T₂) and then 1, 3, and 5 minutes postintubation (T₃, T₄, and T₅).

Table 1 Demographic data in four groups.

	Group M (n = 50)	Group G (n = 50)	Group F (n = 50)	Group L (n = 50)
Age (y)	73.44 ± 5.17	72.66 ± 4.67	72.94 ± 5.19	73.00 ± 5.60
Sex (M/F)	23/27	25/25	24/26	21/29
BMI (kg.m ⁻²)	23 ± 3.9	22 ± 2.7	23 ± 2.1	23 ± 2.8
ASA class 1/2	41/9	44/6	42/8	46/4

All data were presented as mean ± SD or numbers, $p > 0.05$.

**Figure 1** CONSORT flow diagram.**Table 2** Changes in Systolic (SBP) and Diastolic (DBP) Blood Pressures, and Heart Rate (HR) in four groups.

Group	Pre- induction (T ₀)	Pre-intubation (T ₁)	Post-intubation (T ₂)	Minutes post-intubation		
				1 (T ₃)	3 (T ₄)	5 (T ₅)
Group M						
SBP (mmHg)	132 ± 10.12	113 ± 15.72	135 ± 9.36	124 ± 13.69	115 ± 12.91	109 ± 15.38
DBP (mmHg)	86 ± 10.12	73 ± 13.29	93 ± 14.12	87 ± 14.66	82 ± 15.39	75 ± 13.34
HR (bpm)	75 ± 12.54	71 ± 12.59	92 ± 13.92	84 ± 10.22	82 ± 11.38	80 ± 10.29
Group G						
SBP (mmHg)	129 ± 15.38	112 ± 12.72	133 ± 16.29	125 ± 17.48	116 ± 16.25	110 ± 18.21
DBP (mmHg)	84 ± 14.63	75 ± 15.27	92 ± 14.61	85 ± 12.42	80 ± 13.21	74 ± 15.73
HR (bpm)	74 ± 13.51	71 ± 10.63	93 ± 10.91	82 ± 9.41	82 ± 10.43	81 ± 11.40
Group F						
SBP (mmHg)	133 ± 14.29	112 ± 16.94	132 ± 12.40	118 ± 17.25	113 ± 14.90	109 ± 16.30
DBP (mmHg)	83 ± 13.53	74 ± 14.37	91 ± 12.62	86 ± 14.85	81 ± 15.84	73 ± 14.39
HR (bpm)	76 ± 12.62	70 ± 13.82	95 ± 11.47	81 ± 9.92	80 ± 12.34	77 ± 13.24
Group L						
SBP (mmHg)	129 ± 16.39	114 ± 13.51	116 ± 14.32 ^a	113 ± 16.25	110 ± 14.38	107 ± 15.23
DBP (mmHg)	84 ± 15.57	75 ± 14.38	80 ± 15.41 ^a	79 ± 16.25	76 ± 15.39	73 ± 16.18
HR (bpm)	77 ± 13.05	74 ± 11.60	82 ± 12.58 ^a	80 ± 9.03	79 ± 12.67	78 ± 12.91

Group M, Macintosh laryngoscope; Group G, Glidescope; Group F, Fiberoptic bronchoscope; Group L, Lightwand.

^a $p < 0.05$ compared to Group M, G and F (Only intergroup significances are showed).

Catecholamine measurement

Plasma catecholamine levels were drawn at T₀, T₁ and T₂. Catecholamine blood samples for measuring Epinephrine (E) and Norepinephrine (NE) were collected into Ethylenedi-

aminetetraacetic Acid (EDTA) tubes. Plasma catecholamines were determined by High-Performance Liquid Chromatography (HPLC) with electrochemical detection using methods that were previously described.²⁵ The reference blood lev-

els were up to 0.45 nmol.L⁻¹ for E and up to 2.40 nmol.L⁻¹ for NE.

Sample size and statistical analysis

The sample size was calculated by the PASS software (version 11.0; NCS, Kaysville, UT). Power studies suggested that a sample size of 44 patients per group was required to achieve a power of 90% at a 0.05 level of significance for detection of differences across the four groups. Therefore, we *a priori* decided to include 200 patients (50 patients per group), in case of a general 15% of patients' dropouts.

All data were analyzed using ANOVA in SPSS software, version 19.0 for Microsoft Windows (Chicago, IL, USA). The quantitative variables are represented as the mean \pm SD, and the qualitative variables are shown as case numbers (percentages, %). The χ^2 test was used to analyze qualitative variables. All tests were 2-tailed, and the significance level for the statistical analysis was set to $p < 0.05$.

Results

A total of 213 patients were assessed for eligibility, 13 patients were excluded on the grounds of the patient's refusal to participate and the risk for regurgitation and aspiration. Eventually, a total of 200 patients were enrolled in this study. There were 50 patients in each group. The characteristics of the patients are presented in Table 1. There were no significant differences among the four groups in age, sex, gender, or ASA status ($p > 0.05$).

SBP, DBP and HR data analysis revealed that, after anesthetic induction (T₁), there were significant decrease in SBP, DBP and HR in all patients compared with T₀, as seen in Fig. 1A, 1B, and 1C, respectively ($p < 0.05$). SBP, DBP and HR values significantly increased with the completion of intubation at T₂ for groups M, G and F, but group L showed only a slight increase. SBP, DBP and HR values finally returned to almost the same level in the four groups. SBP, DBP and HR were not significantly different at any measurement time for group L and showed a stable profile across the entire study period. The intergroup comparison showed that group L had significantly lower SBP, DBP and HR values at T₂ than the other groups. All inter- and intra-group comparisons of SBP, DBP and HR data are shown in Table 2.

Catecholamine plasma levels are shown in Figures 2D and 2E. Preinduction (T₀) catecholamine concentrations decreased significantly after the induction of anesthesia. There was no significant difference in epinephrine levels among the groups at the matched time points. The plasma norepinephrine levels in groups F and L at T₂ showed less fluctuation than those of the other two groups. Catecholamine plasma data are presented in Table 3.

All intubations were completed within two attempts through the assigned intubation equipment. Groups F and L had higher success rates on the first attempt than groups M and G ($p < 0.05$) (Table 4). However, only group L had a significantly different duration of intubation compared to the other groups ($p < 0.05$) (Table 4 and Fig. 2F).

Table 3 Serum catecholamine changes.

	Group M		Group G		Group F		Group L	
	E (nmol.L ⁻¹)	NE (nmol.L ⁻¹)	E (nmol.L ⁻¹)	NE (nmol.L ⁻¹)	E (nmol.L ⁻¹)	NE (nmol.L ⁻¹)	E (nmol.L ⁻¹)	NE (nmol.L ⁻¹)
Pre-induction	0.191 \pm 0.07	1.63 \pm 0.35	0.228 \pm 0.04	1.59 \pm 0.31	0.211 \pm 0.07	1.69 \pm 0.48	0.205 \pm 0.09	1.55 \pm 0.32
Pre-intubation	0.124 \pm 0.05	1.14 \pm 0.41	0.136 \pm 0.09	1.03 \pm 0.42	0.118 \pm 0.04	1.21 \pm 0.30	0.137 \pm 0.06	1.13 \pm 0.27
Post-intubation	0.091 \pm 0.008	1.43 \pm 0.37	0.083 \pm 0.003	1.49 \pm 0.26	0.092 \pm 0.005	1.19 \pm 0.31 ^a	0.101 \pm 0.004	1.10 \pm 0.37 ^a

E, Epinephrine; NE, Norepinephrine.

Group M, Macintosh laryngoscope; Group G, Glidescope; Group F, Fiberoptic bronchoscope; Group L, Lightwand.

^a $p < 0.05$ compared to Group M, G and F (Only intergroup significances are showed).

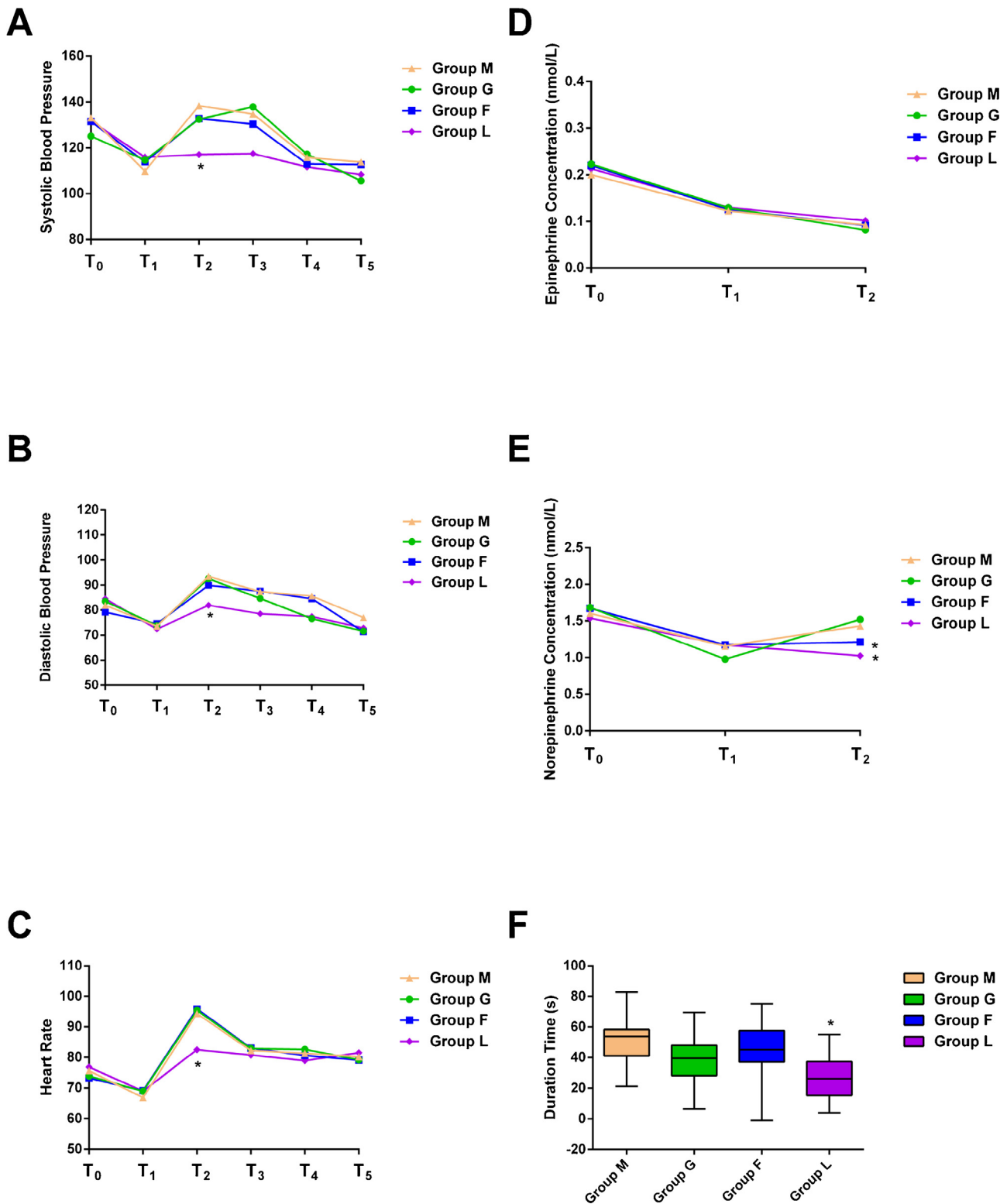


Figure 2 (A, B and C) Systolic blood pressure, diastolic blood pressure and heart rate changes, respectively, during the study period. (D and E) Epinephrine and norepinephrine concentrations (nmol.L⁻¹). (F) Total intubation time using each intubation device, mean ± SD. Group M, Macintosh laryngoscope; Group G, Glidescope; Group F, Fiberoptic bronchoscope; Group L, Lightwand.

Postoperative complications for dental or gum injury, hoarseness, and sore throat are described in Table 4. There were no statistically significant differences among

groups M, G and F, but group L had lower incidences of complications than the other three groups ($p < 0.05$) (Table 4).

Table 4 Success rate, duration of intubation, and post-operation complications.

	Group M	Group G	Group F	Group L
Success rate at first time	10/40 (80%)	11/39 (82%)	5/45 (90%) ^a	3/47 (94%) ^a
Duration time	46.24 ± 14.35	39.71 ± 11.94	41.39 ± 13.28	25.47 ± 11.58 ^a
Hoarseness	4/46 (8%)	3/47 (6%)	0 ^a	0 ^a
Sore throat	12/38 (24%)	7/43 (12%)	2/48 (4%) ^a	3/47 (6%) ^a
Loss of teeth	5/45 (10%)	6/44 (12%)	5/45 (10%)	0 ^a
Dental or gum injury	7/43 (14%)	5/45 (10%)	4/46 (8%) ^a	0 ^a

Group M, Macintosh laryngoscope; Group G, Glidescope; Group F, Fiberoptic bronchoscope; Group L, Lightwand.

^a $p < 0.05$ Group F or L compared to Group M or G (Only intergroup significances are showed).

Discussion

Due to the poor conditions of elderly patients, they often suffer more than younger people during general surgery because of intubation stimulation. Therefore, there is an urgent need to seek safer intubation devices to reduce the risk for elderly patients.

In our study, we compared the effects of the four different intubation devices for elderly patients during general anesthesia and observed reduced fluctuations in HR, SBP and DBP in group L. While reductions in sore throat, dental injury, hoarseness, and loss of teeth and a higher success rate were shared with group F, shorter intubation time was solely found for group L. Moreover, norepinephrine levels in groups L and F were also more stable than in the other groups after intubation. Therefore, elderly patients' stress responses to tracheal intubation using the Lightwand seem to be less than in the other groups, and the Lightwand had a shorter intubation duration.

A growing number of research studies have demonstrated that dental disease causes a large difference in nutrition intake, arrhythmias, and cognitive disorders, including Alzheimer's disease and dementia.^{26,27} This point highlights the importance of tooth protection during surgery to prevent postoperative complications. Elderly patients always suffer from more severe dental abnormalities, emphasizing the need for appropriate intubation devices to prevent diseased teeth or tooth loss.²⁸ Our data showed that the Lightwand had considerable advantages for protecting elderly patients' teeth and causing fewer postoperative complications. These differences might occur because the Lightwand is smaller and softer. The shorter intubation time could also be a reason for this finding.

The hemodynamic response associated with intubation tubes and intubation is transient and ends within minutes; however, it can be harmful to some groups of patients, especially elderly patients. There is already literature demonstrating that the hemodynamic response to a tracheal cannula was not significantly different between the Lightwand and the Glidescope with a normal airway.²⁹ However, it was also reported that the Lightwand caused less stimulation of hemodynamic responses in patients with difficult airways.³⁰ In our study, our results were similar to studies of difficult airways since the incidence of hypertension was higher in the other three groups than in the Lightwand group. There are several possible explanations for this outcome. First, elderly people have greater sensitivity to stimulation. Second, intubation using the Glidescope, the

Macintosh laryngoscope, and the Fiberoptic bronchoscope requires more time than that using the Lightwand.

In our study, plasma catecholamine levels did not increase after induction of general anesthesia in any group. There have been other papers that evaluated plasma catecholamines using two intubation techniques, and these results agreed with our results for plasma catecholamine levels.^{4,16,31} Although a correlation among HR, SBP, DBP and catecholamines might be anticipated, this idea still requires further evaluation because our results did not show any correlations.

Our results demonstrated that the success rate on the first attempt in groups L and F was higher, but the total intubation time was significantly shorter using only the Lightwand than when using the other intubation techniques. There were no significant differences among the Macintosh laryngoscope, the Glidescope and the Fiberoptic bronchoscope in total intubation time. These differences were likely due to the different procedural methods required during the intubation process compared to the procedures for familiar devices.

There were some limitations of our study. First, the number of study patients was not very large, and the patients' experience with the specific devices varied. Second, we studied only these four devices in our department's facilities. There are several alternatives for other hospitals, and this study cannot draw conclusions about all intubation equipment. Finally, it is also possible that hemodynamics repercussions and time to insert the tracheal tubes can differ with nasal intubation compared to oral intubation and techniques being blinded with possible risk of damage to soft tissues by the Lightwand.

Conclusion

This study was the first study to compare four different types of intubation devices for their influence on hemodynamic responses and postoperative complications in elderly patients with normal airways. Our results demonstrated that the Lightwand might be the best choice for anesthetists to conduct tracheal intubation in elderly patients who are more vulnerable to operative complications.

Conflicts of interest

None of the authors of this paper has a financial or personal relationship with other people or organizations that could

inappropriately influence or cause bias in the content of the paper.

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