Annals of Otolaryngology Head and Neck Surgery
Case Report (ISSN 2835-7132)

Styletubation For Routine Tracheal Intubation for Ear-Nose-Throat Surgical Procedures

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Citation: *Hsiang-Ning Luk, Jason Zhensheng Qu, Alan Shikani. Styletubation For Routine Tracheal Intubation for Ear-Nose-Throat Surgical Procedures. Annal of Otol Head and Neck Surg. 2023;2(3):1-13.*

Received Date: 29 May, 2023; **Accepted Date:** 06 June, 2023; **Published Date:** 12 June, 2023

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ABSTRACT

Direct laryngoscope and videolaryngoscope are the dominant endotracheal intubation tools. Styletubation technique (using a video-assisted intubating stylet) has been demonstrated the advantages including shorter intubation time, high first-attempt success rate, less stimulation, and high operator's satisfaction. Like many procedures, there is a learning curve to master the technique of styletubation. Special attention should be paid to conditions such as space-occupying lesions, secretions/blood, stiff neck, restricted mouth opening, etc. In this clinical report, we present the effectiveness and efficiency of routine use of the styletubation technique for tracheal intubation in various ear-nose-throat surgical procedures.

Keywords: Styletubation; Tracheal intubation; Laryngoscopy; Videolaryngoscope; Video-assisted intubating Stylet; Anesthesia; Ear-nose-throat surgeries; Difficult airway

INTRODUCTION

Laryngoscopy is a procedure to visualize the oro-pharynx and larynx and a first step for biopsy, removal of a mass/foreign body, and tracheal intubation.[1,2] Direct laryngoscopy (DL) is performed with a conventional laryngoscope, constructed with a blade and a handle. The design of DL is to open patient's airway, visualize the glottis opening, and to facilitate the endotracheal intubation.[3] Various technical pearls have been proposed to increase the success rate of tracheal intubation.[4-13]

Even with the structured training courses and hands-on clinical experiences of applying conventional laryngoscopy, the learning curve for novice airway trainees was slow and clinical skill proficiency for airway operators remained to be challenged. Loosing the airway has devastating consequences to both the patients and clinicians.[14-17] Most causes for such airway disasters are attributed to difficult ventilation and difficult intubation. Incidents of "cannot-oxygenate" may eventually lead to airway-related morbidity and mortality.

Clinical practice reviews and guidelines for difficult airway management have been periodically revised and promulgated.[18-20]

The advent of rigid indirect videolaryngoscopes (VL) is among the many innovative designs of airway tools that improve the outcomes of difficult airway and minimize complications.[21-23] Many studies have been published including elective versus emergency intubation, routine versus difficult airway, operating room versus outside operating room, etc.[24] However, whether the VL should routinely be chosen over DL for tracheal intubation remains a matter of debate. Prior to the optic/video device of VL, similar concepts of the rigid optic intubating "scope" for difficult intubation had already been introduced e.g., the Bonfils intubation fiberscope.[25-27] A new "seeing" intubation stylet-scope for difficult airway was invented.[28] After more than two decades of clinical evaluation, this video-assisted intubating stylet technique has recently been coined as "styletubation" for both routine and difficult tracheal intubation.[29]

Airway management in patients undergoing ear-nose-throat (ENT) surgeries is one of the most challenging scenarios.[30-34] Awake flexible fiberoptic bronchoscope (FOB) is still considered as the gold standard for tracheal intubation.[35] In addition to awake/asleep FOB technique, others (e.g., VL, intubating laryngeal mask, etc) are playing more roles in tracheal intubation for difficult intubation.[36-39] Among the emerging tools is the optic intubating stylet.[40] In this brief report, we demonstrate the routine use of styletubation (Figure 1) as the main tracheal intubation tool in patients undergoing various ENT surgeries.

Figure 1: Styletubation (video-assisted intubating stylet technique, VS). A: Two-person model (mouth-opening with jaw-thrust by an assistant) B: One-person model (a video-laryngoscope is used). VS: S-RVL video stylet, Sensorendo Medical Technology, Room 1501, 3# Building, Tsinghua High-Tech Park, Zhuhai City, Guangdong Province, China.

CASE SERIES PRESENTATION

The following VS devices are routinely used in our department: (1) TuoRen Kingtaek video intubating stylet, TuoRen, Henan TuoRen Medical Device Co., Xinxiang, Henan, 453401, China. (2) UE rigid laryngoscope and

TRS video stylet, Zhejiang UE Medical Corp., Taizhou, 317300, China. (3) C-MAC-VS (Video Stylet), KARL STORZ SE & Co. KG, Tuttlingen, Germany; (4) Trachway video intubating stylet, Markstein Sichtech Medical Corp., Taichung, 407, Taiwan. American Society of Anesthesiologists (ASA) standard monitoring (including electrocardiogram (ECG), non-invasive blood pressure (NIBP), pulse oximeter (SpO_2), peripheral nerve stimulator (train-of-four, ToF), and capnogram (end-tidal CO_2, $ETCO_2$) was applied intra-operatively. The induction and maintenance of anesthesia followed our routine protocols, including medications of glycopyrrolate, midazolam, fentanyl, propofol, rocuronium, and sevoflurane or desflurane. All tracheal intubations were routinely performed with the styletubation technique with a video intubating stylet (Figure 1). It should be noted that, pre-operatively, the ENT specialists workforce were always consulted and shared-decision was made for any potential or anticipated difficult airway.

Case 1 (Chronic otitis media)

A 49-year-old woman (height 165 cm, weight 50 kg, body mass index (BMI) 18.3 kg/m^2) suffered chronic otitis media of her right ear. She underwent type III tympanoplasty with mastoidectomy, and ossiculoplasty. Pre-operative airway evaluation revealed interincisor distance 4 cm, thyromental distance 5 cm, sternomental distance 14 cm, neck circumference 35 cm, modified Mallampati class II, and upper lip bite test class 1. Intubation with styletubation was smooth and easy. The intubation time (from lip to trachea) was 6 s with first-pass success. The laryngeal view and glottic visualization were clear and the tracheal ring was identified before advancing the endotracheal tube into trachea (Figure 2, A-C). No airway stimulation or injuries were noted during intubation.

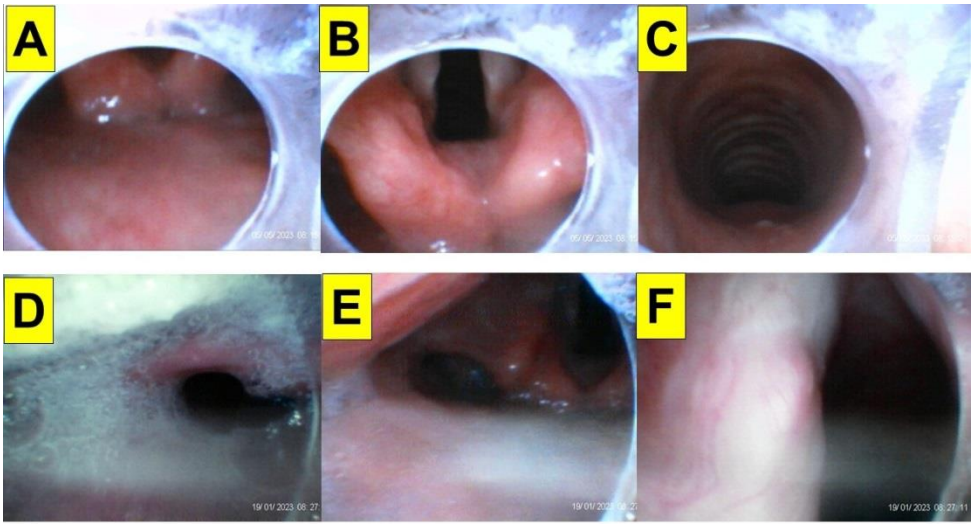

Figure 2: Chronic otitis media (Case 1, A-C) and chronic paranasal sinusitis (Case 2, D-F). A: laryngeal view. B: glottis view. C: tracheal view. (see Video S1 in the Supplementary Materials). D: laryngeal view. E: glottis view. F: vocal cords. Secretions-obscured the views was noted in the Case 2. (see Video S2 in the Supplementary Materials).

Case 2 (Chronic paranasal sinusitis)

A 78-year-old man (height 170 cm, weight 88 kg, BMI 30.4 kg/m^2) suffered from chronic paranasal sinusitis (CPS). He underwent bilateral functional endoscopic sinus surgery (FESS). Pre-operative airway evaluation

revealed as the following: interincisor distance 4 cm, thyromental distance 5 cm, sternomental distance 14 cm, neck circumference 44 cm, modified Mallampati class III, upper lip bite test class 2. Intubation with styletubation was smooth and easy. The intubation time (from lip to trachea) was 26 s with first-pass success, even in the presence of copious secretions and saliva (Figure 2, D and E). The laryngeal view and glottic visualization were identified and advancement of endotracheal tube into trachea was smooth (Figure 2, D-F). No airway stimulation or injuries noticed during intubation procedure.

Case 3 (Tongue carcinoma)

A 53-year-old man (height 166 cm, weight 60 kg, BMI 21.7 kg/m^2) suffered tongue carcinoma (squamous cell carcinoma, pT4aN0M0, PNI(+)). He underwent tracheostomy, wide excision of tumor and partial glossectomy, bilateral neck dissection (superior omohyoid neck dissection), and fasciocutaneous flap reconstruction. Pre-operative airway evaluation revealed as follows: poor dentition, interincisor distance 4 cm, thyromental distance 4 cm, sternomental distance 16 cm, neck circumference 37 cm, modified Mallampati class IV, upper lip bite test class 3. The intubation time (from lip to trachea) was 20 s with first-pass success. The laryngeal view and glottic visualization were clear and tracheal ring was identified before advancing the endotracheal tube into trachea (Figure 3, A-C). No dental or airway stimulation/injuries occurred during intubation procedure.

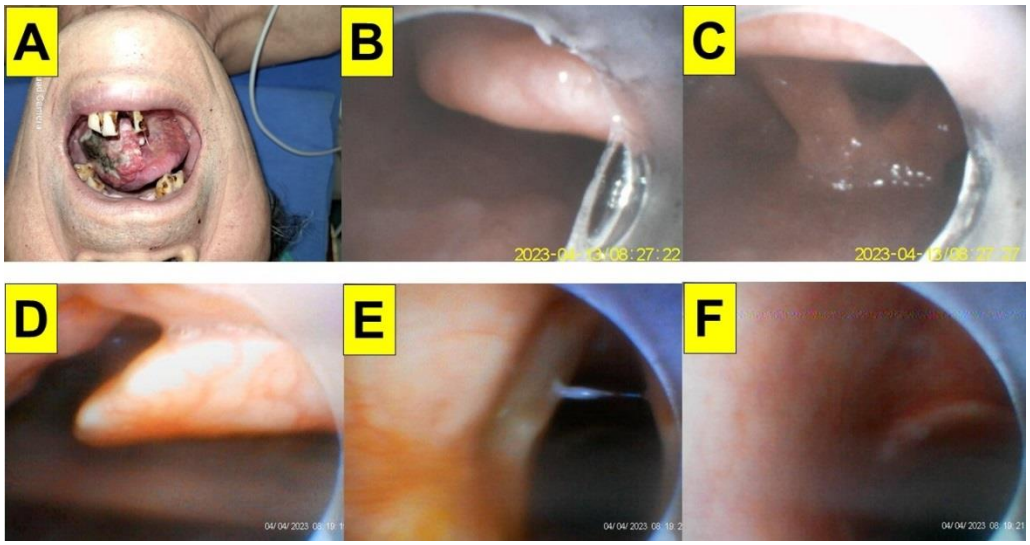

Figure 3: Tongue cancer (Case 3, A-C) and lip cancer (Case 4, D-F). A: oral cavity view. B: laryngeal view. C: glottis view. Poor dentition was noticed. (see Video S3 in the Supplementary Materials) D: laryngeal view. E: glottis view. F: trachea. (see Video S4 in the Supplementary Materials)

Case 4 (Lip carcinoma)

A 74-year-old man (height 160 cm, weight 49 kg, BMI 19.1 kg/m^2) suffered lower lip squamous cell carcinoma (pT1). He underwent tracheostomy, wide excision, Estlander and Karapandzic flaps for reconstruction. Pre-operative airway evaluation revealed as follows: interincisor distance 4 cm, thyromental distance 5 cm, sternomental distance 16 cm, neck circumference 35 cm, modified Mallampati class III, upper lip bite test class 2. The intubation procedure with styletubation was smooth and easy. The intubation time (from lip to trachea) was 10 s with first-pass success. The laryngeal view and glottic visualization were clearly identified and advancement

of endotracheal tube into trachea was smooth (Figure 3, D-F). No airway stimulation or injuries occurred during intubation procedure.

Case 5 (Chronic tonsillitis)

A 14-year-old woman (height 151 cm, weight 56 kg, BMI 24.5 kg/m^2) suffered chronic rhinitis, obstructive sleep apnea (OSA) and grade IV chronic tonsillitis. She underwent tonsillectomy and uvulopalatopharyngoplasty (UPPP). Pre-operative airway evaluation revealed as follows: interincisor distance 4 cm, thyromental distance 5 cm, sternomental distance 16 cm, neck circumference 33 cm, modified Mallampati class II, upper lip bite test class 1. The intubation time (from lip to trachea) was 16 s with first-pass success. The laryngeal view and glottic visualization were clear and tracheal ring was identified before advancing a non-kinking reinforced endotracheal tube into trachea (Figure 4, A-C). No airway stimulation or injury occurred during intubation procedure.

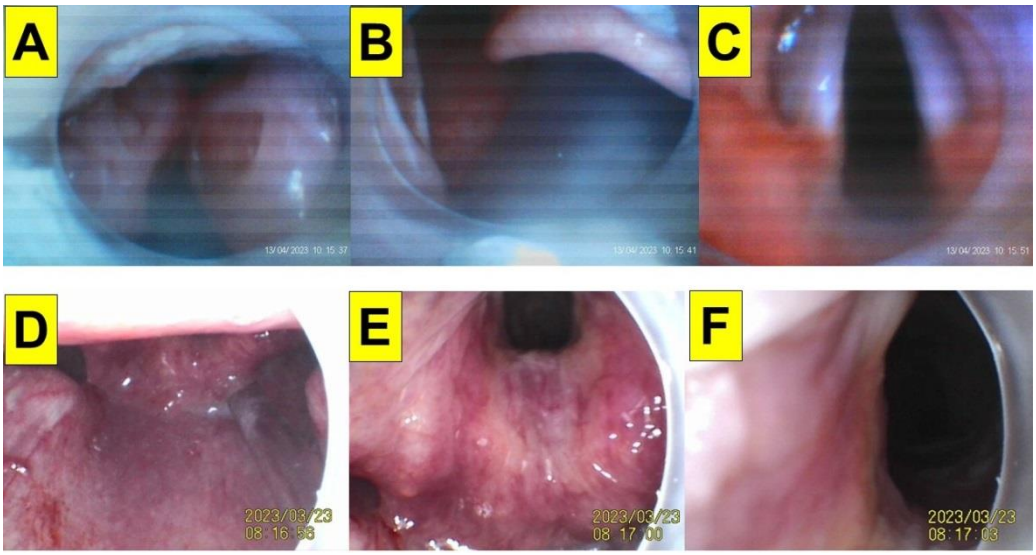

Figure 4: Chronic tonsillitis (Case 5, A-C) and buccal cancer (Case 6, D-F). A: oral cavity view. B: laryngeal view. C: glottis view. Obstruction of the pharyngeal entry by the enlarged tonsils was noticed. (see Video S5 in the Supplementary Materials) D: laryngeal view. E and F: glottis view. (see Video S6 in the Supplementary Materials)

Case 6 (Buccal carcinoma)

A 65-year-old man (height 169 cm, weight 78 kg, BMI 27.3 kg/m^2) suffered skull base benign tumor and underwent neurosurgical removal procedure. His past medical history included hypertension, diabetes mellitus, end-stage renal disease with hemodialysis, and malignant neoplasm of lower gum and left buccal carcinoma (squamous cell carcinoma, pT2N0). Wide excision of left buccal tumor with selective neck dissection, marginal mandibulectomy, and cutaneous free flap reconstruction were performed three years prior to this admission. The intubation procedure with styletubation was smooth and easy. The intubation time (from lip to trachea) was 16 s with first-pass success. The laryngeal view and glottic visualization were clearly identified and advancement of a non-kinking reinforced endotracheal tube into trachea was smooth (Figure 4, D-F). No airway stimulation or injuries occurred during intubation procedure.

Case 7. (Nasopharyngeal carcinoma)

A 81-year-old man (height 159 cm, weight 52 kg, BMI 20.5 kg/m^2) suffered nasopharyngeal carcinoma (cT4N1M0, type 3, under concurrent chemoradiotherapy) and left vocal cord palsy. He was admitted to our hospital this time due to adenocarcinoma of ascending colon (pT3N2bM0, stage 3C) and scheduled to undergo laparoscopic right hemicolectomy. Pre-operative airway evaluation revealed as follows: hoarseness, stiff neck, interincisor distance 3.5 cm, thyromental distance 6 cm, sternomental distance 14 cm, neck circumference 32 cm, modified Mallampati class III, upper lip bite test class 2. The intubation procedure with styletubation was smooth and easy. The intubation time (from lip to trachea) was 8 s with first-pass success. The laryngeal view and glottic visualization were clear and tracheal ring was identified before advancing the endotracheal tube into trachea (Figure 5, A-C). No airway stimulation or injuries occurred during intubation procedure. For demonstration purpose, a video-laryngoscope had been inserted into the patient's oral cavity before styletubation was performed. It should be emphasized that, with such video-video twin technique, the styletubation can be easily conducted by a single airway operator.

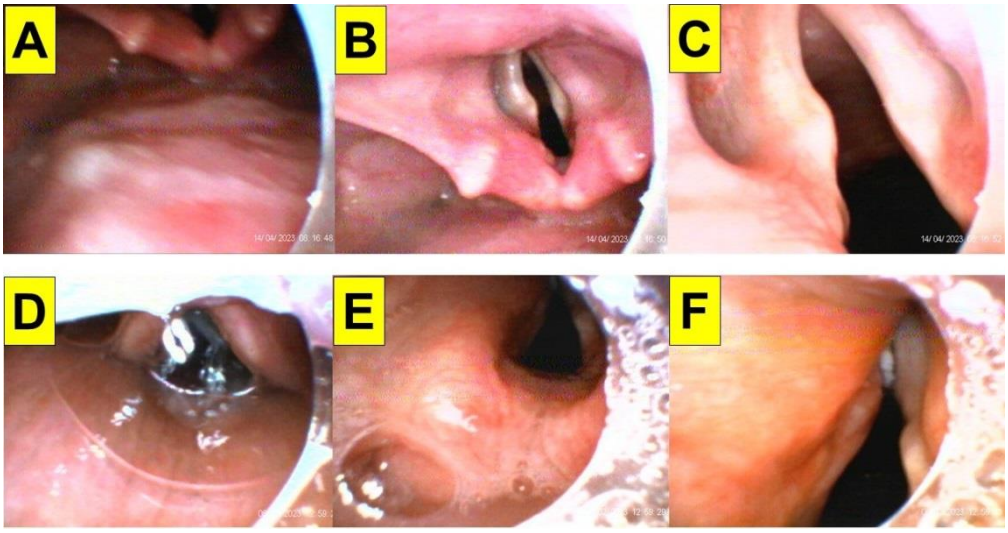

Figure 5: Nasopharyngeal carcinoma (Case 7, A-C) and vocal cord cancer (Case 8, D-F). A: laryngeal view. B: glottic view. C: vocal cords view. (see Video S7-S8 in the Supplementary Materials) D: laryngeal view. E and F: glottis view. Vocal cord tumor lesion can be seen. (see Video S9 in the Supplementary Materials)

Case 8. (Vocal cord carcinoma)

A 91-year-old man (height 180 cm, weight 77 kg, BMI 23.7 kg/m^2) suffered left vocal cord squamous cell carcinoma (pT3). He underwent total laryngectomy, right total thyroidectomy, and permanent tracheostomy. Pre-operative airway evaluation revealed as follows: interincisor distance 5 cm, thyromental distance 6 cm, sternomental distance 16 cm, neck circumference 40 cm, modified Mallampati class III, upper lip bite test class 2. The intubation procedure with styletubation was smooth and easy. The intubation time (from lip to trachea) was 21 s with first-pass success. The speed of intubation was purposely slowed down to examine the lesion over the vocal cords. The laryngeal view and glottic visualization were clear and tracheal ring was identified before advancing the endotracheal tube into trachea (Figure 5, D-F).

Case 9. (Hypopharyngeal carcinoma)

A 76-year-old man (height 152 cm, weight 56 kg, BMI 23.9 kg/m^2) underwent tracheostomy. He suffered hypopharyngeal carcinoma (supraglottic squamous cell carcinoma, cT3N0M0) and received adjuvant concurrent chemoradiation therapy (CCRT). Past medical history included complete AV block, hypertension, and heart failure. A permanent pacemaker (DDD mode) was implanted. Pre-operative computed tomography of head and neck (with and without contrast media) revealed abnormal enhancing mass lesion about 27 X 30 X 31 mm in size at the left hypopharynx with aryepiglottic folds involvement (Figure 6, A-B). Asymmetrical obliteration of left pyriform sinus is also noted, confirmed by flexible nasal endoscopy (Figure 6, C-D). Pre-operative airway evaluation revealed as follows: interincisor distance 4 cm, thyromental distance 6 cm, sternomental distance 15 cm, neck circumference 39 cm, modified Mallampati class III, upper lip bite test class 2. To determine the feasibility of applying oral tracheal intubation technique in this patient, a nasal flexible intubation videoendoscope (Karl Storz) was applied to check the patency and the pathway of the airway in advance (Figure 6, E-F). After discussing with the ENT attending physician, the anesthetized styletubation was cautiously performed. The intubation procedure was smooth and easy. The intubation time (from lip to trachea) was 21 s with first-pass success. The intubation was purposely slowed down to examine the lesion over the glottis areas. The laryngeal view and glottic visualization were clear and tracheal ring was identified before advancing the endotracheal tube into trachea (Figure 7).

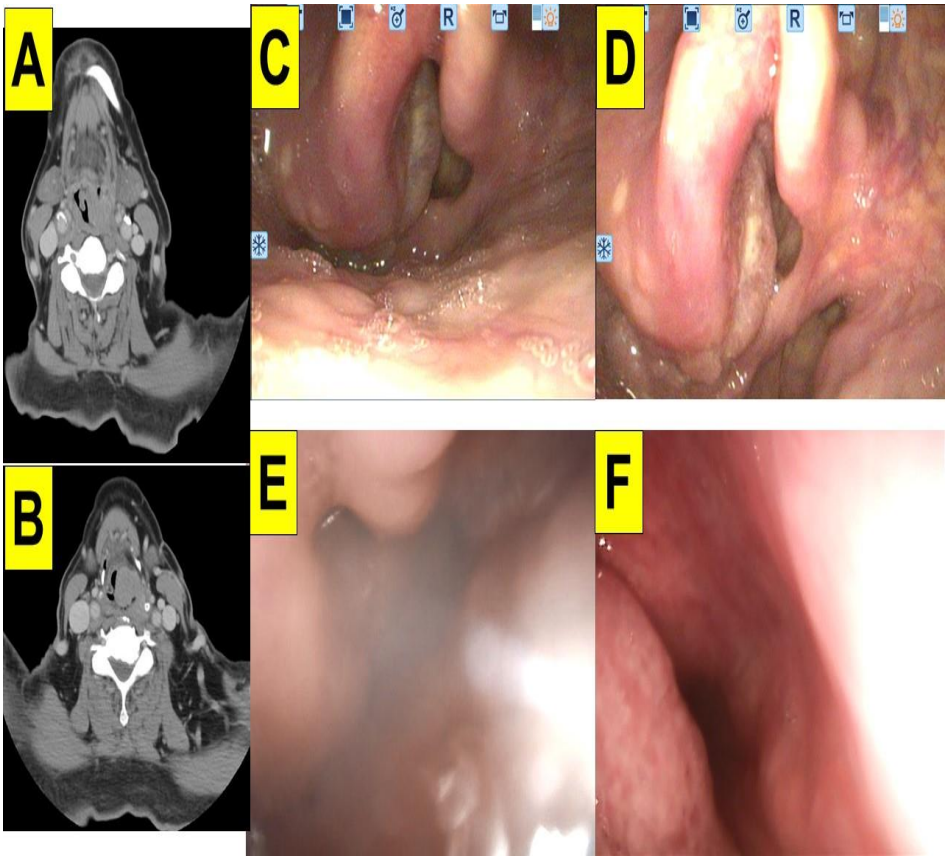

Figure 6: Hypopharyngeal carcinoma (Case 9). A and B: CT scan images. C and D: glottis images acquired by flexible nasal endoscopy. E and F: glottis view acquired by FOB. Vocal cord tumor lesion can be seen. (see Video S10 in the Supplementary Materials)

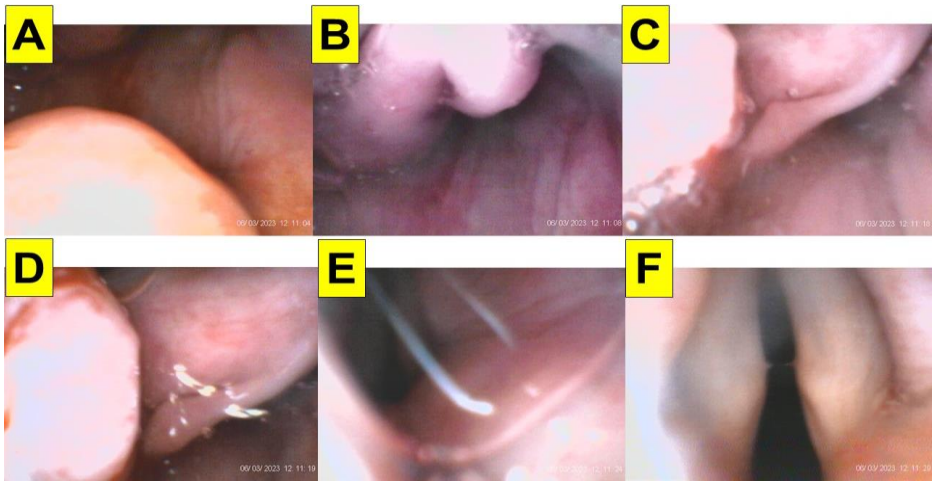

Figure 7: Hypopharyngeal carcinoma (Case 9). Images from the styletubation. A: uvula. B: epiglottis. C and D: before turning around the tumor lesion. E and F: vocal cords can clearly be seen. (see Video S11 in the Supplementary Materials)

DISCUSSION

In this brief report, we presented the application of styletubation to conduct tracheal intubation in patients undergoing various ENT surgeries. These patients are categorized into to those who have abnormal anatomical structures or physiology in the airway.[41,42] Examples include oral maxillofacial anomalies, enlarged tonsils or glands, radiation of the neck stiff neck, pharyngeal/laryngeal tumors, etc. The airway management in this patient population is challenging.[43,44]

Common difficult airway problems are associated with morbid conditions such as obesity, ankylosing spondylitis, limited mouth opening, restricted neck mobility, tumor mass or reconstructed flap impeding the airway, massive blood or secretions obstructed airway visibility, etc. These airway conditions create challenges for intubation with DL. FOB (alone or assisted by DL, VL, or intubating supraglottic devices) has traditionally been chosen in these scenarios. The paradigmatic role of VL (alone or in combination with FOB) for difficult airway management has been increasingly recognized since it was introduced decades ago.[24,45] In patients with known difficult airway, videolaryngoscopy has added value in improving first-time success rate, obtaining better view of the glottis, and reducing mucosal trauma.[46]

There has been a paradigm shift in the routine use of styletubation for tracheal intubation.[29,47] The styletubation can be used for elective/emergency, routine/difficult airway, in the operating rooms and non-operating rooms, etc. Table 1 shows our extensive clinical experience and routine application of styletubation in an 1110-bed tertiary medical center in Taiwan. In our department of 21 operating rooms, there are 25 sets of video intubating stylets. The total number of patients with styletubation for tracheal intubation is around 7000 cases a year. The rest were intubated either with FOB or DL/VL, for teaching purposes or indications needed. As the cases presentation in this article, we routinely applied the styletubation technique in those patients who were also the candidates for VL application. FOB or even elective tracheostomy are reserved for those where styletbuation was considered to be contraindicated. The styletubation has the advantages of shorter intubation time, very high first-pass success rate,

much less tissue injuries or complications, and most important, the high subjective satisfaction and comfort by the airway operators (Table 2).

Table 1: Use coverage of video-assisted intubating stylet in the Hualien Tzu-Chi Medical Center, Hualien, Taiwan.

		2016	2017	2018	2019	2020	2021	2022
Total Anesthesia Number		16077	17831	17998	19307	19721	19244	19765
GA Number		15339	16893	17497	18481	19009	18574	19061
LMA-GA Number		5544	5134	5816	5902	5863	5714	4932
ET-GA Number		5953	6504	6920	6966	7418	6982	7602
	VL Number	0	0	20	100	635	336	305
	VS Number	5953	6504	6900	6866	6783	6646	7297

Hualien Tzu-Chi Hospital is an 1110-bed tertiary medical center in the east coast of Taiwan island. GA: general anesthesia; LMA: laryngeal mask airway; ET: endotracheal tube; VL: videolaryngoscopy; VS: video-assisted intubating stylet (styletubation technique).

Table 2: A comparison of the generalized advantages and disadvantages of using VL and VS (styletubation) for tracheal intubation.

	VL	VS
Affordability	Expensive	Moderate
Availability	++	++
Accessibility	++	++
Maintenance	Easy	Easy
Learning Curve	Fast	Faster
Team Performance	+++	+++
Rescue for Difficult/Failed Intubation	++	+++
Combined Use with Other Tools	FOB	DL/VL/FOB
Use in ER, ICU, and EMT Settings	+++	+++
View Quality on Video Monitor	+++	+++
Required Use of a Laryngoscope Blade	+	-
Required Wide Mouth-Opening	++	+
Glottic View	++	+++
Lifting Force	++	-
Required to Align Airway Axes	++	-
Need for External Manipulation	++	-
Difficulty Inserting ET Tube	+	-
Difficulty Maneuvering ET Tube	-	-
Stylet Requirement	++	-
Impact of Collapsed Epiglottis	+	+++
Impact of Secretions on the Lens	++	+++
First-Attempt Success Rate	+++	+++
Intubation Time	short	shorter
Look-Around the Corner	++	+++
Esophageal Intubation Incidence	+	-
Autonomic Stimulation	++	-
Airway Complications	+	-
Awake Intubation	++	++
Operator's Subjective Satisfaction	++	+++

Note: DL, direct laryngoscope, VL, videolaryngoscopy; VS, video-assisted intubating stylet; FOB, fiberoptic bronchoscope; SGA, supraglottic airway device; ICU, intensive care unit; ER, emergency room; EMT, emergency medical technician; ET, endotracheal tube.

The main limitations of this case series report include (1) the retrospective study design of case-report; (2) the limited possibility of generalizing the reliability and validity of the study results due to the small number of subjects; and (3) the fact that the clinical performance was conducted by a single airway operator in a single tertiary medical center. Therefore, the application and interpretation of this case series report results should be carefully considered within a much broader context to avoid the unnecessary overstatement of the validity of the study. Although currently both DL and VL still play important roles in airway management in many countries and regions, the emergence of the new styletubation technique has gradually prevailed over recent years in Taiwan. This styletubation technique has been demonstrated to be effective and efficient in both routine airway management and certain difficult clinical scenarios, such as head/neck tumors, morbid obesity, restricted cervical spine mobility, rapid sequence intubation, cardiopulmonary resuscitation, etc.[29,47] However, according to the current guidelines, it should be mentioned that when a difficult airway (e.g., difficult laryngoscopy, face mask ventilation, emergency invasive airway, etc.) is anticipated/suspected, the awake intubation option should be seriously considered in advance.[20] In conclusion, we demonstrate that the styletubation can be well applied in patients undergoing various ENT surgeries. Such application to certain potential difficult airway scenarios, however, should be carefully evaluated preoperatively, in teamwork with ENT doctors.

Supplementary Materials: The following supporting information can be downloaded at
https://youtu.be/kARw1LIKw94
https://youtu.be/HMcJCFNb0R4
https://youtu.be/bxLK8GQOlxg
https://youtu.be/mzTQ-tTP1T0
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https://youtu.be/vO7K_VkjDOE
Videos S1-S2 (Figure 2), Videos S3-S4 (Figure 3), Video S5-S6 (Figure 4), Video S7-S9 (Figure 5), Video S10 (Figure 6), Video S11 (Figure 7).

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