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ORIGINAL ARTICLE

Lingual traction to facilitate fiber-optic intubation of difficult airways: a single-anesthesiologist randomized trial

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Abstract
Purpose Flexible fiber-optic bronchoscope-guided orotracheal intubation is a valuable technique with demonstrated benefits in the management of difficult airways. Despite its popularity with anesthesia providers, the technique is not fail-safe and airway-related complications secondary to failed intubation attempts remain an important problem. We sought to determine the effect of incorporating lingual traction on the success rate of fiber-optic bronchoscope-guided intubation in patients with anticipated difficult airways.

Methods In this prospective, randomized, cohort study, we enrolled 91 adult patients with anticipated difficult airways scheduled for elective surgery to undergo fiber-optic bronchoscope-guided orotracheal intubation alone or with lingual traction by an individual anesthesiologist after induction of general anesthesia and neuromuscular blockade. A total of 78 patients were randomized: 39 patients to the fiber-optic bronchoscope-guided intubation with lingual traction group and 39 patients to the fiber-optic bronchoscope-guided intubation alone group. The primary endpoint was the rate of successful first attempt intubations. The secondary outcome was sore throat grade on post-operative day 1.

Results Fiber-optic intubation with lingual traction compared to fiber-optic intubation alone resulted in a higher success rate (92.3 vs. 74.4 %, $\chi^2 = 4.523$, $p = 0.033$) and greater odds for successful first attempt intubation (OR 4.138, 95 % CI 1.041–16.444, $p = 0.044$). Sore throat severity on post-operative day 1 was not significantly different but trended towards worsening grades with lingual traction.

Conclusions In this study, lingual traction was shown to be a valuable maneuver for facilitating fiber-optic bronchoscope-guided intubation in the management of patients with anticipated difficult airways.

Keywords Lingual traction · Fiber-optic intubation · Difficult airway

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Introduction

Flexible fiber-optic bronchoscope-guided orotracheal intubation (FOI) is a valuable technique in the management of difficult airways for many anesthesia providers [1, 2].

However, Han et al. [3] recently found a first attempt intubation success rate of only 34.1 % for FOI in patients without difficult airways. As previously reported in the literature, repeated intubation attempts were associated with an increased risk of airway-related complications [4–6]. Consequently, the identification of additional strategies to facilitate management of the difficult airway is essential in reducing the associated patient morbidity.

Lingual traction is a familiar technique for facilitating laryngoscopic tracheal intubation. This maneuver provides two distinct anatomic advantages in clearing the tongue away from the soft palate and uvula and lifting the epiglottis from the posterior pharyngeal wall [7–9]. While lingual traction with FOI has been found to be valuable in patients with anticipated normal airways and cervical spine disease, we did not identify any reports in the literature evaluating its effects in patients with difficult airways [8, 9].

Previous studies have evaluated lingual traction and jaw thrust as adjuncts for FOI in difficult airway management. Archdeacon and Brimacombe [8] and Rewari et al. [10] previously advocated the benefit of lingual traction for difficult FOI. Durga et al. assessed airway clearance with a fiber-optic bronchoscope using jaw thrust, lingual traction, and both maneuvers simultaneously. While the authors found jaw thrust to be superior to lingual traction for clearing the epiglottis from the posterior pharyngeal wall and the opposite for clearing the tongue from the uvula and soft palate, applying the techniques together opened the airway at both levels for all patients [9]. Han et al. [3] demonstrated that the jaw thrust maneuver added to FOI resulted in a significantly higher first attempt intubation success rate compared to FOI alone (70.7 vs. 34.1 %) through facilitating tracheal tube advancement over a fiber-optic bronchoscope. However, both studies excluded patients with potentially difficult airways or known histories of difficult intubation.

The hypothesis of the present study was that incorporating lingual traction as an adjunct to FOI would significantly increase the first attempt intubation success rate in patients with anticipated difficult airways compared to FOI performed alone. Therefore, this randomized study comparatively evaluated FOI with and without lingual traction in patients with anticipated difficult airways undergoing general anesthesia.

Methods

Study design

In this prospective, randomized, cohort study (ClinicalTrials.gov Identifier: NCT01958346), we compared FOI with lingual traction to FOI alone in patients with anticipated difficult airways. We conducted our study at a single institution, Tampa General Hospital, in Tampa, Florida, USA. The study protocol was approved by the facility's institutional review board on June 26, 2012 (registration number: Pro00008289), and written informed consent was provided by all participating patients.

Patients and randomization

During the enrollment period, patients were screened for study eligibility at the time of their standard anesthesia preoperative evaluation; 3–5 days prior to their scheduled surgery. Patients were eligible for inclusion in the study if they were >18 years old, classified as ASA physical status I–III, scheduled to undergo elective surgery requiring orotracheal intubation, and determined to have an anticipated difficult airway on preoperative evaluation. The following factors were identified in the literature and used to identify patients with difficult airways: limited cervical spine mobility, large tongues, obesity (body mass index > 30 kg/m^2), short and large necks (circumference > 47 cm), decreased oral aperture (interincisal distance < 30 mm), short thyromental distance, a poorly visualized hypopharynx, modified Mallampati classification III or greater, protruding incisors, small mandibles, prognathism, cervical trauma, history of difficult intubation, or other oral or cervical deformities [1, 2, 4, 11, 12].

Patients were excluded from the study if they were classified as ASA physical status IV, pregnant, required rapid-sequence induction, at risk for pulmonary aspiration of gastric contents, required a non-standard endotracheal tube, or unable to provide written consent.

Written informed consent was provided by each patient on the day of surgery. Computerized randomization was performed under the guidance of an independent biostatistician to randomly assign patients on a 1:1 ratio to undergo FOI with lingual traction or FOI alone. Treatment assignments were blinded to the patient and biostatistician, but the research staff and authors remained aware of the treatment groups.

Study treatment

On the day of surgery, patients underwent routine standard preoperative evaluations and preparations by one of two different anesthesiologists not present at the initial screening or involved in performing FOI and/or lingual traction. At this time, the patients' airway status was reassessed to confirm their eligibility for the study. If these anesthesiologists concluded that the anticipated difficult airway would require awake intubation, then those patients were excluded from the study after enrollment and prior to

randomization. All inductions of general anesthesia were performed with propofol and midazolam and tracheal intubations were managed and performed by a single anesthesiologist experienced in FOI. Patients were brought to the operating room, placed in semi-Fowlers position (supine position with head of bed elevated to 30 degrees from horizontal), and preoxygenated to an end-tidal oxygen concentration of $\geq$80 % prior to total intravenous anesthesia induction with propofol and lidocaine. The patient group assignments were provided to the investigator after transfer to the operating room and prior to induction of general anesthesia. All necessary resources for fiber-optic intubation were available in the operating room regardless of patient assignment. Additionally, the second anesthesiologist required to perform the lingual traction maneuver was stationed outside of the operating room on standby without group assignment knowledge until the time of randomization. After induction, patients were exposed to 100 % oxygen until neuromuscular blockade with succinylcholine was verified for intubation. At this point, lingual traction was performed for assigned patients by a second anesthesia provider who manually grasped the tongue with dry gauze and applied gentle forward traction until resistance was met (Fig. 1). The amount of force applied for lingual traction was not objectively measured or directed. Orotracheal intubation was initiated for both patient groups with the placement of a Williams airway intubator (10 cm, pink) into the pharynx followed by introduction of the fiber-optic bronchoscope. For all patients, the use of external laryngeal manipulation, jaw thrust, and/or repositioning of the patient's head and neck was permitted at any point to facilitate intubation at the discretion of the performing anesthesiologist. After establishing the epiglottic view, the fiber-optic bronchoscope was advanced into the trachea and a standard high-volume, low-pressure polyurethane-cuffed tracheal tube (7.0 for females and 8.0 mm for males) (Kimberly-Clark Microcuff, Neenah, WI, USA) was passed over the fiber-optic bronchoscope into proper position. Successful tracheal intubation was confirmed when the end-tidal CO_2 exceeded 2.7 kPa (20 mmHg) for more than five consecutive breaths with a normal-appearing capnographic tracing. Failure to intubate was determined by the intubating anesthesiologist if an adequate view of the glottic opening could not be obtained prior to the patient requiring additional oxygenation/ventilation, the endotracheal tube could not be properly positioned, or when tracheal intubation could not be confirmed by end-tidal CO_2 monitoring. If patients in the FOI alone group had a failed first intubation attempt, lingual traction was applied in subsequent intubation attempts as a rescue maneuver. For the lingual traction group, repeat intubation attempts were conducted similarly to the first intubation attempt without any required, specific, or defined changes. After three total failed intubation attempts, patients would be removed from the study and undergo awake fiber-optic intubation.

Outcome measures

The primary outcome was the rate of successful first-attempt intubations. We defined this end point as the ability to visualize the pharynx and glottic opening, enter and securely intubate the trachea, and confirm endotracheal intubation without requiring repeated attempts at any stage. The secondary outcomes were sore throat grade on post-operative day (POD) 1, total number of intubation attempts required, and the overall success rates in each group. Sore throats were qualitatively scored by the patient as none, mild, moderate, or severe.

Statistical analysis

The power analysis and sample-size calculations were performed according to an assumption provided by the single experienced operator in the study. For patients with a difficult airway, the addition of the lingual traction maneuver would result in a 95 % success rate for tracheal intubations on the first attempt. Without the lingual traction maneuver, 65 % of tracheal intubations would be successful on the first attempt. This study was designed to have 80 % power to detect a true 25 % method difference using Fisher's exact test, assuming a single sided α of 0.05. The study was powered for the primary objective only, and a total of 39 patients per group were required.

The Chi-square test and *t* test were conducted for demographic characteristics and baseline measures. Outcome measures were analyzed using Chi-square tests and logistic regression models. The odds ratio (OR) and 95 % confidence interval (95 % CI) were computed for the primary outcome. All tests were considered significant at $\alpha = 0.05$, two-tailed. All analyses were based on the intention-to-treat sample and completed using SPSS 17.0 (SPSS Inc., Chicago, IL, USA).

Results

Patients

From November 2012 through June 2013, 91 patients were enrolled into the study. However, five patients were excluded for safety concerns prompting awake intubation, four patients declined to participate, two patients from each treatment group did not receive the allocated intervention if the primary anesthesiologist was unavailable at the time of patient preparation and induction of general anesthesia, and

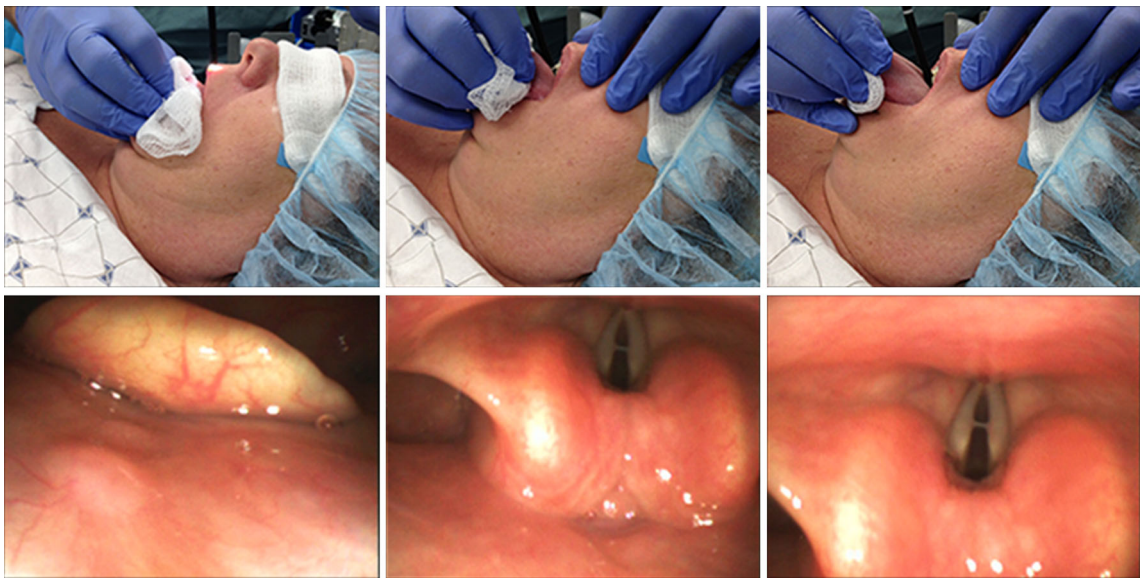

Fig. 1 Depiction of the lingual traction maneuver. From *left* to *right*, bronchoscopic images corresponding to absent, partial, and complete lingual traction are shown in a single patient. The subjective rating of the view ranges from poor to excellent

78 patients underwent randomization (Fig. 2). Baseline characteristics were similar between the two patient groups (Table 1). Data on the primary and secondary outcomes were available for all patients, and analyses were performed on 39 patients in the FOI with lingual traction group and 39 patients in the FOI alone group.

Successful first-attempt intubation

Successful first-attempt tracheal intubation occurred in 36 out of 39 (92.3 %) patients in the FOI with lingual traction group and 29 out of 39 patients (74.4 %) in the FOI alone group ($\chi^2 = 4.523$, $p = 0.033$). The odds for successful first-attempt endotracheal intubation in the FOI with lingual traction group was significantly greater than the FOI alone group (OR 4.138, 95 % CI 1.041–16.444, $p = 0.044$). If the first attempt failed in either group, lingual traction, whether repeated or added, permitted successful intubation at the second or third attempt for all patients.

Sore throat severity grade on post-operative day 1

While there was no statistically significant difference in the sore throat grade on POD 1, there was a trend towards an increased proportion of patients experiencing sore throat of any severity in the FOI with lingual traction group compared to the FOI alone group. The presence of sore throat was reported in 14 out of 39 patients (35.9 %) in the FOI with lingual traction group and ten out of 39 patients (25.6 %) in the FOI alone group ($\chi^2 = 0.963$, $p = 0.326$). The sore throat grade in the FOI with lingual traction versus FOI alone groups is as follows: 1 vs. 2 (severe), 5 vs. 1 (moderate), and 8 vs. 7 (mild). No sore throat was reported in 25 out of 39 patients (64.1 %) in the FOI with lingual traction group versus 29 out of 39 patients (74.4 %) in the FOI alone group.

Total number of intubation attempts required and overall success rate for intubation

For both the total number of intubation attempts required and overall success rate for intubation, there were no statistically significant differences between the study groups. Patients who required additional intubation attempts received lingual traction regardless of their assignment. In the FOI alone group, seven patients were successfully intubated on the second attempt whereas three patients required three attempts. For the lingual traction group, two patients required two attempts while one patient was successfully intubated on the third attempt. The overall success rate of intubation was 74.4 vs. 92.3 % with one attempt, 92.3 vs. 97.4 % with two attempts, and 100 vs. 100 % with three attempts in the FOI alone and lingual traction groups, respectively.

Discussion

In this randomized trial involving patients with an anticipated difficult airway, we found that incorporating lingual traction significantly increased the rate and odds of

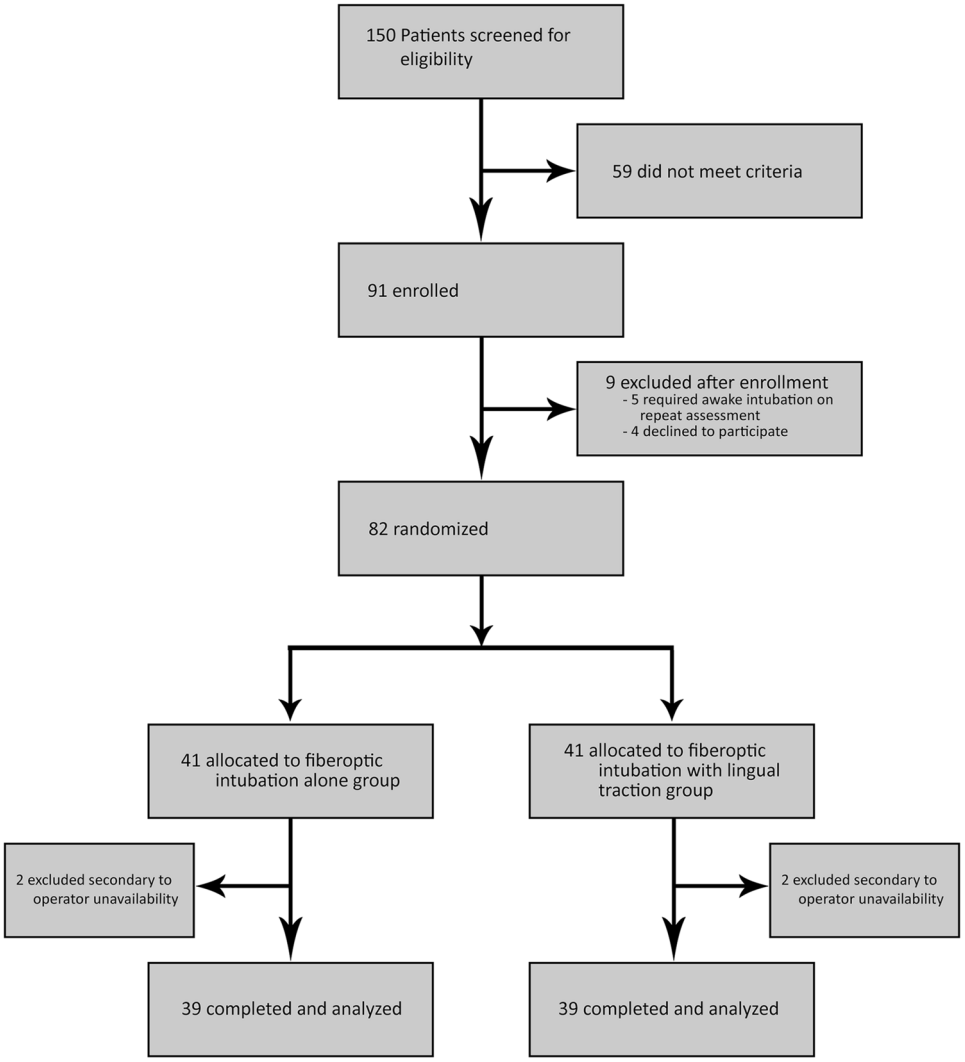

Fig. 2 Consort statement flow diagram

Table 1 Patient demographics

	FOI alone ($n = 39$)	FOI + lingual traction ($n = 39$)	*P* value
Gender (male/female)	19/20	18/21	0.821
Age (year) mean ± SD	55.4 ± 12.5	56.7 ± 13.9	0.681
BMI (kg/m^2) mean ± SD	43.7 ± 10.5	40.6 ± 7.9	0.150
ASA classification ± SD	2.87 ± 0.47	2.90 ± 0.38	0.792
Modified Mallampati score ± SD	3.05 ± 0.40	2.95 ± 0.22	0.161

p values of <0.05 are considered statistically significant based upon the Chi-square test or Fisher's exact test

BMI body mass index

successful first-attempt FOI. Failure to establish an adequate airway can result from the inability to effectively visualize the glottic opening. Lingual traction is useful in allowing the intubator to identify the appropriate anatomy and facilitating successful management of the difficult airway.

Postoperative sore throat is associated with laryngeal and pharyngeal trauma caused by airway manipulation and endotracheal tube placement [13]. Despite the greater success rate for first attempt intubation with the use of lingual traction, we observed a propensity for more severe sore throat grading on POD 1 in this group. We are unable to determine the exact influence of lingual traction on postoperative sore throat, but we postulate that the act of grasping and pulling the tongue may directly cause trauma to the involved laryngeal and pharyngeal structures or indirectly by altering the passage of the fiber-optic bronchoscope and endotracheal tube. However, variations in intubation technique, use of anesthetic lubricants, endotracheal tube size and intracuff pressure, and the methods used for patient questioning have been found to impact postoperative sore throat severity [13].

Despite the potential benefits of lingual traction with FOI in managing the difficult airway, this maneuver is not without its flaws. Trauma to the tongue can be caused by the grasping and pulling motion or the passage of the FOB or tracheal tube. A tongue injury can lead to pain, bleeding, infection, and other potential complications. Also, performing lingual traction with FOI requires an assistant, which draws additional resources. This problem can often be mitigated by nurse anesthetists, surgeons, or other members of the surgical team who are already present for the case. Nevertheless, lingual traction is a simple, quick, and easy maneuver that can be of great benefit in difficult airway management.

Our study has several limitations. First, our results have limited external validity because every intubation was performed by a single anesthesiologist with extensive experience in fiber-optic intubation. We are unable to determine if lingual traction would provide similar benefit to an anesthesiologist with less familiarity with this technique. Second, our study design did not provide for sufficient blinding of the participating anesthesiologists and increases the opportunities for bias. Third, the operator was able to indiscriminately employ any other maneuver to facilitate tracheal intubation, which may have mitigated or distorted the benefit of lingual traction creating a performance bias. Fourth, the assistant performing lingual traction was not constant (three board-certified anesthesiologists participated at random), and subsequently, the uniformity and quality of this maneuver is uncertain. Fifth, a sampling bias may have occurred though no significant baseline differences were seen between the two patient groups. Sixth, we did not record the reasons for failed intubation attempts and are unable to conclude how lingual traction or any other factors may have helped overcome these problems. Lastly, we did not control for the previously mentioned factors that have been implicated in the development of postoperative sore throat. As such, the significance of postoperative sore throat in our patients is unclear.

In conclusion, lingual traction can be of benefit in facilitating FOI of the anticipated difficult airway. Further study will need to be performed to evaluate the role of lingual traction in the management of the unanticipated difficult airway and as a rescue maneuver for failed difficult airway intubation.

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Conflict of interest The authors do not have any commercial or non-commercial affiliations, conflicts of interests, or any other associates to disclose.

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