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Lightwand Tracheal Intubation with and without Muscle Relaxation

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Background: **Lightwand tracheal intubation is a suitable technique for patients who are difficult to intubate but who are receiving effective ventilation. The effect of muscle relaxants on the efficacy of lightwand intubation has not yet been evaluated. The authors conducted a prospective, double-blind, placebo-controlled study to assess the effectiveness and incidence of complications of lightwand tracheal intubation performed during general anesthesia with and without the use of a muscle relaxant in patients with apparently normal airway anatomy.**

Methods: **One hundred seventy-six patients who required orotracheal intubation were prospectively included. Anesthesia was administered using propofol (2 mg/kg, then 3 mg · kg^{-1} · h^{-1}) and remifentanil (1 μg/kg, then 0.3 μg · kg^{-1} · min^{-1}). Patients were randomly assigned to one of two groups (n = 88 for each) to receive rocuronium 0.6 mg/kg or saline intravenously. Lightwand orotracheal intubation (Trachlight®; Laerdal Medical Inc., Armonk, NY) was attempted after 3 min. The authors recorded the number of successful intubations, the number of attempts and their duration, and events during the procedure.**

Results: **The failure rate of lightwand intubation was 12% in the placebo group and 2% in the rocuronium group ($P = 0.021$). Patients in the placebo group received more multiple intubation attempts ($P < 0.001$), required a greater intubation time (77 ± 65 *vs.* 52 ± 31 s; $P = 0.002$) and experienced a greater incidence of events during intubation (61 *vs.* 0%; $P < 0.001$) than patients in the rocuronium group.**

Conclusions: **The use of muscle relaxants in patients with apparently normal airways is associated with a lower failure rate, decreased intubation time, and fewer attempts when performing lightwand orotracheal intubation.**

LIGHTWAND tracheal intubation is a technique in which an illuminated stylet is introduced into the endotracheal tube, and the tip of the tube is directed into the trachea guided by transillumination of the neck tissues.[1] This is a suitable method for difficult tracheal intubation, mainly in patients with limited mouth opening,[2,3] restricted cervical spine movements,[3–5] orofacial distortions,[3,6,7] or unexpected failed intubation.[3,8] Lightwand tracheal intubation has been recommended in the difficult airway algorithm of the American Society of Anesthesiologists within the intubation choices for patients with difficult intubation and effective ventilation with facemask or laryngeal mask airway (nonemergency pathway).[9] Because difficult intubation and difficult mask ventilation are frequently associated,[10] the guidelines recommend in this situation consideration of anesthetic techniques without muscle relaxation, allowing rapid return to spontaneous ventilation if ventilation becomes inadequate.[9] Consequently, to confirm the place of lightwand intubation in the difficult airway management plan, the effect of muscle relaxants on its reliability and safety should be evaluated. Orotracheal intubation during general anesthesia in patients without muscle relaxation has been previously tested with direct laryngoscopy[11–14] and the Fastrach® (*LMA-Fastrach*™; LMA North America, Inc., San Diego, CA)[15] but most of the studies with lightwand tracheal intubation have been undertaken in anesthetized–paralyzed patients[1,3,5] or in awake patients during local anesthesia.[3,16] Based on the results of a previously nonrandomized study evaluating the Trachlight® (Laerdal Medical Inc., Armonk, NY) learning curve,[17] we hypothesized that the rate of success of the lightwand tracheal intubation should be different between patients with or without muscle relaxation.

The goal of this prospective, double-blind, placebo-controlled study was to assess the effectiveness and incidence of events during lightwand orotracheal intubation performed during general anesthesia with and without muscle relaxation in patients with apparently normal airway anatomy.

Materials and Methods

After approval by our institutional research review board (Comité Ético de Investigación Clínica Hospital Universitari Germans Trias i Pujol, Badalona, Spain) and written informed consent had been obtained, we studied 176 adult patients with American Society of Anesthesiologists physical status I or II who required general anesthesia with orotracheal intubation for elective orthopedic, gynecologic, or abdominal surgery. During the preoperative visit, the anesthesiologist noted the age, sex, weight, height, Mallampati class[18,19] (evaluated while the patient was in the sitting position, head fully extended, tongue out with phonation), mouth opening, thyromental distance, and neck circumference at the thyroid prominence. Exclusion criteria included patients with cardiovascular, respiratory, hepatic, renal or neuromuscular diseases (American Society of Anesthesiologists physical status III, IV, or V); uncooperative patients;

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those with a history of gastroesophageal reflux or an increased risk of aspiration; and patients with coagulation disorders. Conditions with congenital or acquired abnormalities of the upper airway, tumors, polyps, trauma, abscesses, inflammation, or foreign bodies in the upper airway were excluded. We also excluded patients with a history of previous difficult intubation or suspected difficult intubation, defined as the presence of a Mallampati class IV, retrognathia, restricted neck movements, or more than two criteria among the following: Mallampati class III, mouth opening less than 35 mm, or thyromental distance less than 65 mm.[20]

On arrival in the operating room, the electrocardiogram, pulse oximetry, noninvasive arterial blood pressure, and capnography were monitored. We measured the baseline values of noninvasive arterial blood pressure, heart rate, and oxyhemoglobin saturation, and these variables were then measured every 3 min during induction of anesthesia. All data were recorded until 15 min after the baseline measurement. Midazolam, 30 μg/kg, was administered intravenously 5 min before induction of anesthesia, and patients were preoxygenated with 100% oxygen *via* a facemask until the oxygen concentration in the expired air reached at least 90%. Anesthesia was induced with 1 μg/kg remifentanil intravenously injected in 60 s, followed by 2 mg/kg propofol intravenously injected within 30 s. Anesthesia was maintained with propofol 3 $mg \cdot kg^{-1} \cdot h^{-1}$ and remifentanil 0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Patients were randomly assigned to one of the two groups by a nurse not involved in the patient's care or data collection, using sequentially numbered envelopes that contained data sheets. The operator performing tracheal intubation was not involved in the anesthesia technique and was consequently blinded to the muscle relaxants use. After verification of adequate mask ventilation, patients received either intravenous rocuronium (0.06 ml/kg of a solution of 10 mg/ml rocuronium, n = 88) or saline (0.06 ml/kg, n = 88). Lightwand orotracheal intubation with the Trachlight® was attempted 3 min later by an anesthesiologist with more than 50 previous experiences of lightwand intubation with Trachlight®. All procedures were performed by the same anesthesiologist (E. M.), with patient's head and neck placed in the neutral position, under ambient light conditions, with the lightwand bent at an angle of 90° and jaw thrust. For male patients, we used 8-mm-ID endotracheal tubes, and for female patients, we used 7.5-mm tracheal tubes. We stopped any attempt that lasted more than 2 min or was associated with the appearance of cough, patient movements, peripheral oxygen saturation less than 92%, or esophageal intubation. In that case, oxygenation with 100% oxygen for 3 min and supplemental bolus dose of propofol (0.5 mg/kg) and remifentanil (0.5 μg/kg) were given before the next attempt. The number of failures, number of attempts and their duration, total intubation time, and events during the whole procedure were recorded. The duration of one attempt was defined as the time elapsed between inserting the Trachlight® into the oral cavity and the verification of tracheal intubation with the visualization of three expiratory carbon dioxide waveforms, during mechanical ventilation with a tidal volume of 10 ml/kg at a respiratory rate of 20 breaths/min.

Total intubation time was defined as the sum of the duration of all intubation attempts (as many as three), excluding the preoxygenation procedures. Failure to intubate was defined as the inability to place the endotracheal tube into the trachea after three attempts. In this case, direct laryngoscopy was performed, and the laryngoscopic Cormack grade[21] and the position of vocal cords (open, closed, or intermediate) were noted. The following events were recorded during the procedure: cough, patient movements, bronchospasm or laryngeal stridor, mucosal or dental trauma, esophageal intubation, and peripheral oxygen saturation less than 92%. Mucosal or dental trauma were defined as the presence of blood on the tip of the Trachlight®, oropharyngeal bleeding, or dental extraction. The presence of bronchospasm, laryngeal stridor, or mucosal or dental trauma were considered an indication of stopping the procedure. Hemodynamic disturbance was defined as a deviation of mean arterial blood pressure or heart rate more than 30% from baseline values. In this case, the anesthesiologist administered intravenous bolus doses of vasoactive drugs when needed. Hemodynamic disturbances were not considered as events because they were mainly related to anesthesia induction.

Possible causes of failure were also noted as laterally deviated transillumination, dim transillumination in the middle of the neck, bright transillumination in the middle of the neck but resistance to advancement of the endotracheal tube, and appearance of any event defined previously.

Statistical Analysis

The main endpoint was the rate of failure of tracheal intubation. A previous study reported a failure rate of lightwand intubation without muscle relaxation of 20%.[17] We tested the hypothesis that muscular relaxation enables a decrease in the failure rate from 20 to 5%. Assuming an α risk of 0.05 and a power of 0.95, we calculated that a sample size of 88 patients per group was required (Nquery 3.0 software; Statistical Solutions Ltd., Cork, Ireland). Randomization was performed using a random number table, and equilibration was obtained every 8 patients.

Comparison of two means was performed using the unpaired Student *t* test, comparison of two proportions using the Fisher exact method. Comparison of several means was performed using repeated-measures analysis of variance.

To analyze variables associated with a failure of tra-

Table 1. Characteristics of the Patients and Their Airway Classification

	Placebo (n = 88)	Rocuronium (n = 88)	*P* Value
Age, yr	45 ± 12	46 ± 12	NS
Weight, kg	71 ± 14	69 ± 12	NS
Height, cm	162 ± 9	161 ± 9	NS
Body mass index, kg/m^2	26.9 ± 5.1	26.4 ± 4.9	NS
Female	60 (68%)	68 (77%)	NS
Male	28 (32%)	20 (33%)	NS
Mallampati class			
I	44 (50%)	57 (65%)	
II	35 (40%)	11 (12%)	< 0.001
III	9 (10%)	20 (23%)	
Thyromental distance, mm	90 ± 14	89 ± 11	NS
Mouth opening, mm	40 ± 6	39 ± 7	NS
Neck circumference, mm	401 ± 51	392 ± 47	NS

Values are mean ± SD or number of patients (%). Because of rounding, adding percentages may not provide a sum of 100%.

NS = not significant.

cheal intubation, a stepwise forward logistic regression analysis was also performed. All significant variables in the univariate analysis were entered in the logistic model. The odds ratio and their 95% confidence interval were calculated.

Data are expressed as mean ± SD and number of patients (%). Statistical analysis was performed using NCSS 6.0 software (Statistical Solutions Ltd.). All *P* values were two-tailed, and a *P* value of less than 0.05 was considered significant.

Results

There were no significant differences between the two groups in age, sex, weight, height, body mass index, thyromental distance, mouth opening, and neck circumference (table 1). There were fewer patients with modified oropharyngeal Mallampati classification grade III in the placebo group compared with the rocuronium group ($P < 0.001$).

The failure rate of lightwand tracheal intubation was 12% in the placebo group and 2% in the rocuronium group ($P = 0.021$; table 2). The number of intubation attempts, total intubation time, and dose of propofol and remifentanil were significantly greater in the placebo group (table 2). The failure rate of intubation on the first attempt was also significantly greater in the placebo group (table 2). There were no significant differences between groups in duration of the first and third intubation attempts, although the mean duration of the second attempt was 12 s longer in the placebo group (table 2). Total intubation time was not significantly different between patients with a Mallampati oropharyngeal view I or II compared with those who were Mallampati III (65 ± 53 *vs.* 60 ± 48 s; not significant [NS]).

The causes and incidence of failure on the first attempt

Table 2. Comparison of Lightwand Intubation between Patients with and without Muscle Relaxation

	Placebo (n = 88)	Rocuronium (n = 88)	*P* Value
Successful intubation	77 (88%)	86 (98%)	0.021
Number of attempts			
1	44 (50%)	63 (72%)	
2	17 (19%)	17 (19%)	< 0.001
3	27 (31%)	8 (9%)	
Total intubation time, s	77 ± 65	52 ± 31	0.002
Duration of first intubation attempt, s	39 ± 21	38 ± 16	NS
Duration of second intubation attempt, s	49 ± 31	37 ± 19	0.05
Duration of third intubation attempt, s	42 ± 24	37 ± 26	NS
Dose of propofol, mg	167 ± 52	148 ± 37	0.005
Dose of remifentanil, μg	117 ± 60	96 ± 31	0.004

Values are mean ± SD or number of patients (%). Because of rounding, adding percentages may not provide a sum of 100%.

NS = not significant.

are shown in table 3. In both groups, these were (1) a central but dim transillumination, (2) resistance to the advancement of the tube despite the visualization of a central bright transillumination, and (3) laterally deviated transillumination. All 13 patients not successfully intubated with the lightwand technique on the third attempt were successfully intubated on the first attempt with a Macintosh laryngoscope. They all had a Cormack-Lehane laryngoscopic view grade of I or II. The position of vocal cords was closed (n = 7) or intermediate (n = 4) in the placebo group and intermediate (n = 1) or open (n = 1) in the rocuronium group.

Events during intubation were more frequent in the placebo group (table 4). In both groups, there were no apparent cases of bronchospasm, laryngeal stridor, or mucosal or dental trauma. There were no significant differences in heart rate, arterial blood pressure, and peripheral oxygen saturation between the two groups (fig. 1). The incidence of hemodynamic disturbance was not significantly different between groups (48 *vs.* 49%; NS).

Neck circumference was significantly smaller in women than in men (385 ± 45 *vs.* 427 ± 48 mm; $P <$

Table 3. Causes of Failure at the First Attempt

	Placebo (n = 44)	Rocuronium (n = 25)	*P* Value
Central dim transillumination	21 (48%)	14 (56%)	NS
Resistance to advancement of the tube	12 (27%)	10 (40%)	NS
Transillumination laterally deviated	2 (5%)	1 (4%)	NS
Events (cough, patient movement, peripheral oxygen saturation <92%, esophageal intubation)	9 (20%)	0 (0%)	0.021

Values are number of patients (%). Because of rounding, adding percentages may not provide a sum of 100%.

NS = not significant.

Table 4. Events during Lightwand Tracheal Intubation

	Placebo (n = 88)	Rocuronium (n = 88)	*P* Value
Coughing	30 (34%)	0 (0%)	< 0.001
Patient movement	22 (25%)	0 (0%)	< 0.001
Esophageal intubation	1 (1%)	0 (0%)	NS
Peripheral oxygen saturation < 92%	1 (1%)	0 (0%)	NS
Any event	54 (61%)	0 (0%)	< 0.001

Values are number of patients (%). Because of rounding, adding percentages may not provide a sum of 100%.

NS = not significant.

0.001). The failure rate of lightwand tracheal intubation was not significantly different between patients with Mallampati oropharyngeal view I or II compared with those with Mallampati III (3 *vs.* 8%; NS). There were no significant differences between patients with or without failure in age (52 ± 11 *vs.* 45 ± 12 yr; NS), body mass index (26.2 ± 6.2 *vs.* 26.7 ± 4.9 kg/m^2; NS), mouth opening (39 ± 6 *vs.* 39 ± 7 mm; NS), or thyromental distance (88 ± 12 *vs.* 89 ± 12 mm; NS). Using multivariate analysis, only three variables were significantly associated with a successful lightwand tracheal intubation: (1) rocuronium group (odds ratio = 6.1; 95% confidence interval, 1.3–28.6), (2) female sex (odds ratio = 3.5; 95% confidence interval, 1.1–10.9), and (3) smaller neck circumference (odds ratio = 1.01 per mm; 95% confidence interval, 1.01–1.02).

Discussion

The failure rate of tracheal intubation with the Trachlight® was only 2% in the rocuronium group compared with 12% in the placebo group ($P = 0.021$). The failure rate of tracheal intubation with the Trachlight® in anesthetized and paralyzed patients with normal airways has been previously estimated as being 1% in a large clinical trial.[1] In our study, the failure rate in patients with muscle relaxation was similar, but significantly higher in the placebo group, probably reflecting poorer intubation conditions due to the lack of relaxation of oropharyngeal and laryngeal muscles.

Female patients and those with smaller neck circumferences were significantly more likely to be successfully intubated with the Trachlight®, but these patients were homogenously distributed in the two groups. The presence of a thick neck could be expected to lead to difficult transillumination but has not yet been related as a cause of failure of lightwand intubation.[1] Nevertheless, body mass index of 30 kg/m^2 or greater has been identified as a factor interfering with the ease and success of lightwand tracheal intubation.[22] In our study, women had a significantly smaller neck circumference of the neck compared with men, probably leading to easier

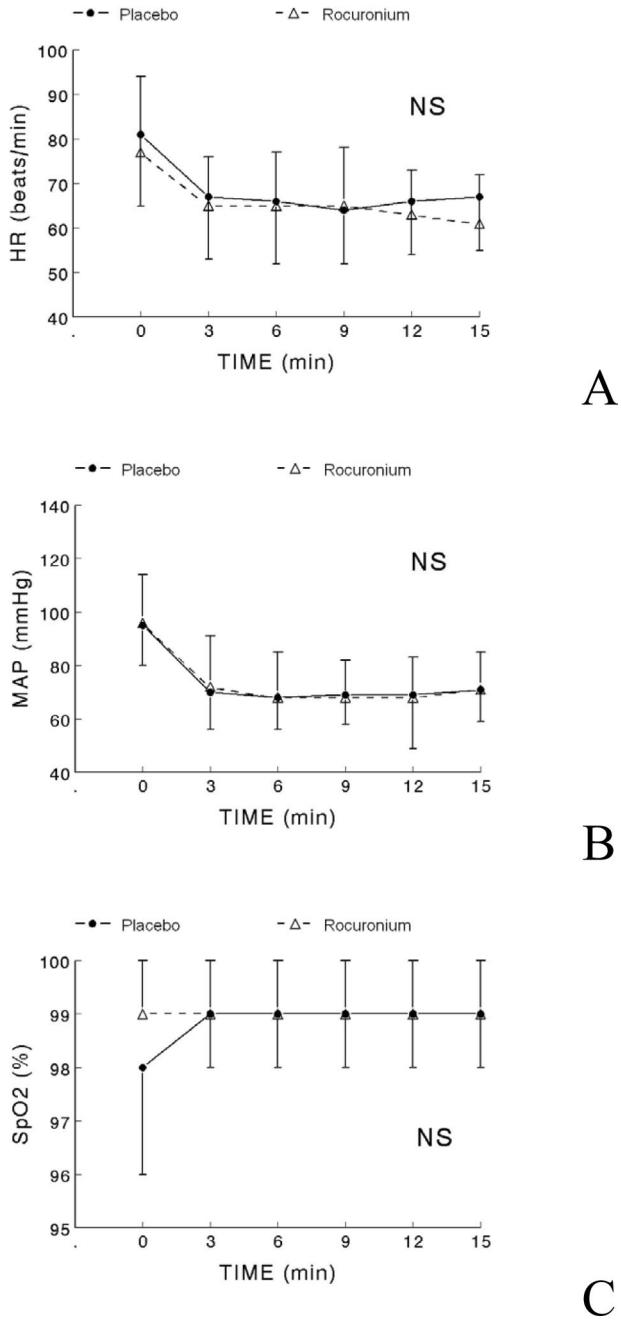

Fig. 1. Variation of heart rate (HR; *A*), mean arterial pressure (MAP; *B*) and peripheral oxygen saturation (Spo_2; *C*) in patients of the placebo (n = 88) and rocuronium (n = 88) groups. *P* values refer to between group differences. NS = not significant.

transillumination. The smaller tube size used in females (7.5 mm ID) compared with males (8 mm) could also have improved success rate in women. However, because our study was performed in apparently nondifficult-airway patients, we did not study other specific characteristics of airway anatomy that can influence lightwand tracheal intubation, such as the distance between the thyroid prominence and the angle of the mandible.[23] Previous studies have related a large tongue and long epiglottis as frequent features in patients with

Trachlight® failure, but they found no significant correlation between ease of lightwand intubation and Mallampati classification of oropharyngeal view.[1] Nevertheless, different data indicate that lightwand tracheal intubation time is prolonged in patients who have modified Mallampati class III compared with classes I or II.[22] In our study, there were more patients with Mallampati class III in the rocuronium group, but the success rate and total intubation time of lightwand tracheal intubation were not significantly different from those in patients with Mallampati classes I or II. These contradictory data suggest that more studies are necessary to know specific predictive factors of difficult lightwand tracheal intubation.

The number of attempts and total intubation time were significantly higher in patients without muscle relaxation, 31% of them requiring three attempts. These patients also received significantly higher doses of propofol and remifentanil, according to the study design. Although the duration of each intubation attempt was not significantly different between groups, the duration of the second attempt was 12 s longer in placebo group ($P = 0.05$). This attempt was begun after first supplemental dose of sedation, which may have partially suppressed the appearance of events as a reason to stop the intubation attempt (coughing and movements of the patient). This would have enabled enough improvement of the laryngeal inlet exposition to introduce the tip of the Trachlight® into the trachea but with the additional risk of triggering hemodynamic disturbances.

A previous study reported a mean lightwand tracheal intubation time of 16 ± 11 s, 92% of cases being successfully intubated on the first attempt.[1] In our study, the total intubation time in the rocuronium group was 52 ± 31 s, with a successful rate at the first attempt of 72%, 9% of these patients requiring three intubation attempts. Although these results are different, they may be explained by the design of our study, where the duration of intubation was measured as the time from inserting the Trachlight® into the oropharynx to the time when three expiratory carbon dioxide waveforms were visualized. In addition, each intubation attempt was stopped when any event occurred, including cough and patient movements. Consequently, some of the additional intubation attempts may reflect inadequate hypnosis or muscle relaxation instead of a true lightwand tracheal intubation failure.

The main causes of intubation failure in the two groups were the presence of a central but dim transillumination or the resistance to advancement of the tube despite the visualization of a central bright transillumination reflecting those patients with a good orientation of the Trachlight® to the middle of the neck but with difficulties in manipulating the tip of the lightwand to reach the laryngeal inlet or to get through it to achieve tracheal intubation. In the placebo group, this can be explained by the absence of relaxation of laryngeal muscles, because in 7 of 11 failure cases, the vocal cords were closed when exposed to laryngoscopic view with a Macintosh laryngoscope, the rest of them being in the intermediate position. Nevertheless, we did not record the incidence of muscle rigidity related to remifentanil administration, which has been estimated in 0.3% with a similar remifentanil regimen[24] and which could have inhibited the passage of the tube. In contrast, in the rocuronium group, the position of vocal cords was intermediate (n = 1) or open (n = 1). These two cases might reflect other causes of failure not analyzed in our study, such as the collapse of oropharyngeal structures, a large floppy epiglottis, and an inadequate preformed angle of the Trachlight® leading to incorrect position in relation to the laryngeal inlet, making lightwand intubation difficult as previously reported.[1,23,25] However, the position of vocal cords was not examined until after three unsuccessful attempts, and laryngoscopy at that point might not reflect the state of relaxation during previous attempts.

The patients were randomly assigned to one of the two groups, and the operators did not know the treatment assigned. We did not ask the operators to which treatment group they thought patients were assigned to, but it is clear that most experienced clinicians could probably detect when muscle relaxants are used when manipulating the airway.

The doses of remifentanil were chosen on the basis of a preliminary study of tracheal intubation with Macintosh laryngoscope without the use of muscle relaxants, where 2.5 mg/kg propofol and 1 $\mu g \cdot kg^{-1} \cdot min^{-1}$ remifentanil provided clinically acceptable intubation conditions.[14] Other studies in intubation techniques without muscle relaxation have recommended a remifentanil dose of 2–5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ associated with a dose of propofol of 2–2.5 mg/kg to obtain good intubation conditions with a Macintosh laryngoscope,[11–13] but in clinical practice, these doses lead to more cardiovascular side effects. In our study, there was no significant difference in heart rate, arterial pressure, or peripheral oxygen saturation between the two groups. Equally, there was no difference in the number of patients who experienced variation of arterial blood pressure or heart rate more than 30% of baseline values (fig. 1).

Events occurred in 9 (20%) of the 44 failures in the placebo group on the first attempt (table 3). These were mainly caused by coughing or patient movement (table 4), but there was also one case of esophageal intubation and one of oxygen desaturation. None of these events were registered in the rocuronium group. We consider that this rate of events in healthy patients with apparently normal airways is not acceptable during tracheal intubation, although in high-risk patients with difficult airway or in a noncontrolled setting, a higher rate of events such as oxygen desaturation is to be expected. In

addition, cough or movements of the patient can increase difficulties of tracheal intubation, promote esophageal intubation, and trigger the presentation of other serious complications, such as bronchospasm, laryngospasm, mucosal or dental trauma, or laryngeal injury. These were not observed in our study.

Last, the lightwand is not an oxygenation device. We have shown an increased success rate of lightwand tracheal intubation technique when muscle relaxation is used, but it must be emphasized that effective mask ventilation should be anticipated.[10] If the lightwand is chosen as an elective technique in settings in which a difficult airway is not anticipated, the use of muscle relaxants could be appropriate. In the difficult airway setting, the lightwand should be used only in awake patients who maintain spontaneous ventilation[16] or in patients during general anesthesia who are receiving effective ventilation with facemask or laryngeal mask airway (nonemergency pathway), as previously recommended.[9,26] In this context, the chance of success of lightwand intubation is greater in the presence of muscle relaxants.

In conclusion, in patients with normal airways, lightwand tracheal intubation with Trachlight® in patients without muscle relaxation has a higher failure rate (12 *vs.* 2%), has a higher intubation time, and requires a greater number of attempts than the same technique performed in patients with muscle relaxation.

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References

1. Hung OR, Pytka S, Morris I, Murohy M, Launcelott G, Stevens S, MacKay W, Stewart RD: Clinical trial of a new lightwand device (Trachlight) to intubate the trachea. ANESTHESIOLOGY 1995; 83:509–14

2. Hartman RA, Castro TJr, Matson M, Fox DJL. Rapid orotracheal intubation in the clenched-jaw patient: A modification of the lightwand intubation technique. J Clin Anesth 1992;4:245–6.

3. Hung OR, Pytka S, Morris I, Murphy M, Stewart RD: Lightwand intubation: II. Clinical trial of a new lightwand for tracheal intubation in patients with difficult airways. Can J Anaesth 1995; 42:826–30

4. Weis FR Jr: Lightwand intubation for cervical spine injuries (letter). Anesth Analg 1992;74:622

5. Inoue Y, Koga K, Shigematsu A: A comparison of two tracheal intubation techniques with Trachlight and Fastrach in patients with cervical spine disorders. Anesth Analg 2002; 94:667–71

6. Cook-Sather SD, Schreiner MS: A simple homemade lighted stylet for neonates and infants: A description and case report of its use in an infant with the Pierre-Robin anomalad. Paediatr Anaesth 1997; 7:233–5

7. Holzman RS, Nargozian CD, Florence B: Lightwand intubation in children with abnormal upper airways. ANESTHESIOLOGY 1988; 69:784–7

8. Weis FR, Hatton MN: Intubation by use of the light wand: Experience in 253 patients. J Oral Maxillofac Surg 1989; 47:577–80

9. American Society of Anesthesiologists Task Force on Management of the Difficult Airway: Practice guidelines for management of the difficult airway: An updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. ANESTHESIOLOGY 2003; 98:1269–77

10. Langeron O, Massó E, Huraux C, Guggiari M, Bianchi A, Coriat P, Riou B: Prediction of difficult mask ventilation. ANESTHESIOLOGY 2000; 92:1229–36

11. Stevens JB, Wheatley L: Tracheal intubation in ambulatory surgery patients: using remifentanil and propofol without muscle relaxants. Anesth Analg 1998; 86:45–9

12. Alexander R, Olufolabi AJ, Booth J, El-Moalem HE, Glass PS: Dosing study of remifentanil and propofol for tracheal intubation without the use of muscle relaxants. Anaesthesia 1999; 54:1037–40

13. Klemola UM, Mennander S, Saarnivaara L: Tracheal intubation without the use of muscle relaxants: remifentanil or alfentanil in combination with propofol. Acta Anaesthesiol Scand 2000; 44:465–9

14. Trabold F, Casetta M, Duranteau J, Albaladejo P, Mazoit JX, Samii K, Benhamou D, Sitbon P: Propofol and remifentanil for intubation without muscle relaxant: the effect of the order of injection. Acta Anaesthesiol Scand 2004; 48:35–9

15. van Vlymen JM, Coloma M, Tongier K, White PF: Use of the intubating laryngeal mask airway: Are muscle relaxants necessary? ANESTHESIOLOGY 2000; 93:340–5

16. Saha AK, Higgins M, Walker G, Badr A, Berman L: Comparison of awake endotracheal intubation in patients with cervical spine disease: The lighted intubating stylet versus the fiberoptic bronchoscope. Anesth Analg 1998; 87: 477–9

17. Langeron O, Lenfant F, Aubrun F, Riou B, Coriat P: Évaluation de l'apprentissage d'un nouveau guide lumineux (Trachlight™) pour l'intubation trachéale. Ann Fr Anesth Reanim 1997; 16:229–33

18. Mallampati SR, Gatt SP, Gugino LD, Desai SP, Waraksa B, Freiberger D, Liu PL: A clinical sign to predict difficult tracheal intubation: A prospective study. Can Anaesth Soc J 1985; 32:429–34

19. Samsoon GL, Young JR: Difficult tracheal intubation: A retrospective study. Anaesthesia 1987; 42:487–90

20. Arné J, Descoins P, Fusciardi J, Ingrand P, Ferrier B, Boudiges D, Ariès J: Preoperative assessment for difficult intubation in general and ENT surgery: Predictive value of a clinical multivariate risk index. Br J Anaesth 1998; 80:140–6

21. Cormack RS, Lehane J: Difficult intubation in obstetrics. Anaesthesia 1984; 39:1105–11

22. Wong SY, Coskunfirat ND, Hee HI, Li JY, Chen C, Tseng CH: Factors influencing time of intubation with a lightwand device in patients without known airway abnormality. J Clin Anesth 2004; 16:326–31

23. Chen TH, Tsai SK, Lin CJ, Lu CW, Tsai TP, Sun WZ: Does the suggested lightwand bent length fit every patient? The relation between bent length and patient's thyroid prominence-to-mandibular angle distance. ANESTHESIOLOGY 2003; 98:1070–6

24. Joshi GP, Warner DS, Twersky RS, Fleisher LA: A comparison of the remifentanil and fentanyl adverse effect profile in a multicenter phase IV study. J Clin Anesth 2002; 14:494–9

25. Hodgson RE, Gopalan PD, Burrows RC, Zuma K: Effect of cricoid pressure on the success of endotracheal intubation with a lightwand. ANESTHESIOLOGY 2001; 94:259–62

26. Wong DT, Lai K, Chung FF, Ho RY: Cannot intubate-cannot ventilate and difficult intubation strategies: Results of a Canadian National Survey. Anesth Analg 2005; 100:1439–46