

Success of Tracheal Intubation with Intubating Laryngeal Mask Airways

A Randomized Trial of the LMA Fastrach™ and LMA CTrach™

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Background: The LMA CTrach™ system (The Laryngeal Mask Company, Singapore) is a development of the LMA Fastrach™ system (The Laryngeal Mask Company, Singapore), with integrated fiberoptic bundles and a detachable liquid crystal display viewer. This randomized study of 271 patients compared tracheal intubation with these two systems.

Methods: In both groups, ventilation was optimized after insertion of the laryngeal mask conduit before proceeding further: intubation with the LMA Fastrach™, and optimizing the conduit placement and view and then intubation with the LMA CTrach™. The first-attempt and overall success rates of tracheal intubation, and the times required, were recorded.

Results: Tracheal intubation was successful on the first attempt in 93.3% of patients with the LMA CTrach™ and 67.9% of patients with the LMA Fastrach™ ($P < 0.001$). The success rates within three attempts were 100% with the LMA CTrach™ and 96.4% with the LMA Fastrach™ ($P = 0.06$). The median (interquartile range) time for the complete tracheal intubation process was 116 (82–156) s with the LMA CTrach™ and 100 (74–121) s with the LMA Fastrach™ ($P = 0.002$). There was no correlation between the grade of conventional laryngoscopy and success of intubation with either system.

Conclusions: The ability to view the glottis and optimize placement of the LMA CTrach™ under vision enabled a higher first-attempt success rate of tracheal intubation with the LMA CTrach™. However, more time is required with the LMA CTrach™, there are failed views in some patients, and its cost effectiveness remains unclear.

THE LMA Fastrach™ (also termed the Intubating Laryngeal Mask Airway™; The Laryngeal Mask Company, Singapore) enables ventilation and provides a conduit for blind tracheal intubation.^{1,2} Since its introduction in 1997, the LMA Fastrach™ has been shown to be very useful in the management of difficult airways, and its role

in management algorithms has been validated.³⁻⁵ However, blind tracheal intubation with the LMA Fastrach™ frequently fails despite corrective maneuvers and multiple attempts at intubation.^{6,7} The success of tracheal intubation on the first attempt was only 80% in a study of 500 subjects.⁶

The LMA CTrach™ system (The Laryngeal Mask Company, Singapore), a new modification of the LMA Fastrach™, consists of a LMA CTrach Airway™ and a detachable LMA CTrach Viewer™. The LMA CTrach™ has fiberoptic channels to convey light from and images to the liquid crystal display viewer. This system enables viewing of the glottis, alignment of the laryngeal mask conduit with the glottis, and tracheal intubation under vision, and may increase first-attempt success in airway rescue situations.⁸⁻¹⁰ Our hypothesis is that such visualization improves the first-attempt success rate of tracheal intubation through a laryngeal mask conduit. In this randomized study, we compared the success rates of tracheal intubation between the LMA Fastrach™ and the LMA CTrach™ to evaluate the impact of visualization.

Materials and Methods

We obtained approval from the institutional review boards of the National University Hospital, National Healthcare Group, Singapore, and the KK Women's and Children's Hospital, Singapore. We obtained written consent from all patients involved in this study. We recruited 271 adult patients scheduled to undergo elective surgery for which tracheal intubation was a required part of the anesthesia technique. We excluded patients who had body mass indexes greater than 35 kg/m², gastroesophageal reflux, gastric tumors, or respiratory disease causing dyspnea on mild exertion and patients who were pregnant, were on opioid therapy, or had not fasted preoperatively for at least 6 h. The randomization and group assignment were only performed after recruitment of the patients. The patients were assigned to the LMA Fastrach™ group or the LMA CTrach™ group using separate block randomization tables (block size 10) for each of the investigators. The investigators all had considerable experience with both the LMA Fastrach™ and LMA CTrach™ systems.

All patients had standard anesthesia monitors attached and preoxygenation before induction of anesthesia with 2–2.5 mg/kg propofol. After checking that the lungs could be ventilated by bag and mask, muscle relaxation was induced with 0.5 mg/kg atracurium. Anesthesia was

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Received from the Department of Anaesthesia, Yong Loo Lin School of Medicine, National University of Singapore, Singapore. Submitted for publication August 31, 2007. Accepted for publication December 31, 2007. Support was provided solely from institutional and/or departmental sources. An abstract of this study was presented at the Annual Meeting of the American Society of Anesthesiologists, San Francisco, California, October 12–17, 2007. The Department of Anaesthesia, National University Hospital, Singapore, has previously been paid by The Laryngeal Mask Company, Singapore, for the costs involved in teaching local and overseas doctors on the use of laryngeal mask products in Singapore, Malaysia, and China. The authors have never received personal payment for such teaching. The departments and the authors in this study have never received any payment for research or evaluation of the LMA CTrach™, other laryngeal mask products, or any other equipment from other companies. The departments purchased all the equipment used in this study.

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maintained with a sevoflurane end-tidal concentration of 2–2.5% delivered in an air–oxygen carrier gas mix. Independent anesthesiology colleagues, who all had at least 3 yr of experience, performed laryngoscopy with a Macintosh laryngoscope (Heine Optotechnik, Herrsching, Germany). They placed the patients' heads and necks in the "sniffing" position, graded the difficulty of laryngoscopy with the Cormack and Lehane scale,¹¹ and only revealed their grading after all airway procedures were completed.

We chose the *LMA Fastrach*TM and *LMA CTrach*TM laryngeal mask airway size according to the patients' body weight, in accordance with the manufacturer's recommendations.^{12,13} We used a size 3 airway and a 7.0-mm-ID endotracheal tube for patients with body weight below 50 kg, a size 4 airway and 7.5-mm endotracheal tube for patients with body weight of 50–70 kg, and a size 5 airway and 8.0-mm endotracheal tube for patients with body weight over 70 kg. We used nondisposable, flexible, cuffed, wire-reinforced *LMA Fastrach*TM tracheal tubes for all patients. We focused the viewer before using the *LMA CTrach*TM and did not adjust this focusing any further during use.

We supported the patients' heads on a silicone donut 4 cm in height and kept their heads and necks in a neutral posture. The *LMA Fastrach*TM or *LMA CTrach*TM was inserted and adjusted, and tracheal intubation was performed with minimal neck movement in all patients. Our anesthesiology colleagues monitored the patients and ensured that the patients' oxygen saturation did not decrease below 95% at any time.

In the *LMA Fastrach*TM group, we inserted the *LMA Fastrach*TM, inflated the cuff, and checked our ability to ventilate the lungs. If ventilation was difficult, we first applied the "up–down maneuver" by withdrawing the *LMA Fastrach*TM by 6 cm and reinserting it, with the cuff still inflated. If this failed, we partially withdrew the *LMA Fastrach*TM, and if this also failed, we completely removed and reinserted the *LMA Fastrach*TM. The same sequence was followed by all investigators. Our goal was adequate ventilation with a tidal volume greater than 7 ml/kg at low inspiratory pressures less than 25 cm H₂O, at a fresh gas flow of 1 l/min. After optimizing ventilation, we used the metal handle to slightly lift the *LMA Fastrach*TM away from the posterior pharyngeal wall, the second step of the Chandy maneuver, before attempting tracheal intubation.³ If there was resistance to the passage of the endotracheal tube, we applied corrective measures based on the depth of endotracheal tube insertion at which resistance was encountered.^{3,12} If resistance was felt after advancing the endotracheal tube 2–2.5 cm beyond the distal opening of the *LMA Fastrach*TM, the up–down maneuver was applied. If resistance was felt within 1 cm when trying to advance the endotracheal tube, a smaller *LMA Fastrach*TM was used. If resistance was felt after advancing the endotracheal

tube 3 cm beyond the distal opening, a larger *LMA Fastrach*TM was used.

We ventilated the lungs in between attempts. We confirmed correct tracheal intubation with end-tidal capnography. We then removed the *LMA Fastrach*TM over the endotracheal tube with the aid of the stabilizer rod. We allowed up to three attempts at tracheal intubation with the *LMA Fastrach*TM, after which tracheal intubation was performed using a Macintosh laryngoscope.

In the *LMA CTrach*TM group, we also optimized ventilation after insertion of the *LMA CTrach*TM using the same sequence of maneuvers as with the *LMA Fastrach*TM, always starting with the up–down maneuver. We then attached the viewer and adjusted the *LMA CTrach*TM to obtain a full view of the glottis. We applied the up–down maneuver to correct epiglottic down-folding. We partially withdrew the *LMA CTrach*TM if it was too deeply inserted with the view centered on the arytenoids instead of the glottis. When secretions caused failed views, we completely removed the *LMA CTrach*TM and cleaned its lens before reinserting it.¹⁴ We continued ventilation of the lungs *via* the *LMA CTrach*TM in between the maneuvers to improve the views, and limited the time to optimize the views to 3 min. We performed tracheal intubation after optimizing the views. If we failed to obtain a full view of the glottis, we used the *LMA CTrach*TM like a *LMA Fastrach*TM for blind tracheal intubation. We confirmed correct tracheal intubation with end-tidal capnography before removing the *LMA CTrach*TM over the endotracheal tube with the aid of the stabilizer rod. Up to three attempts at tracheal intubation were allowed, after which tracheal intubation was performed using a Macintosh laryngoscope.

Our primary outcome measure was the success rate of tracheal intubation on the first attempt, and our secondary outcome measure was the overall success rate of intubation within three attempts. Each insertion of the endotracheal tube through the laryngeal mask conduit was considered as one attempt. We noted the number of intubation attempts required with each system. Times for tracheal intubation were measured from the beginning of first insertion of the laryngeal mask conduit to completion of tracheal intubation. This timing included the time required for removal of the laryngeal mask conduit, confirmation of ventilation with capnography, and use of the Macintosh laryngoscope where intubation with the *LMA Fastrach*TM or *LMA CTrach*TM systems had failed. We also noted the success rates of lung ventilation and the time to achieve ventilation with the *LMA Fastrach*TM or *LMA CTrach*TM. In the *LMA CTrach*TM group, we noted the success rate of viewing the glottis.

Statistical Analysis

We regarded a difference of 15% in the first-attempt success rates of tracheal intubation as clinically mean-

ingful. Previous work had shown a first-attempt success rate of 80% for blind *LMA Fastrach*™ tracheal intubation and of 96% with the *LMA CTrach*™.^{6,8} Thus, 135 patients in each group would enable detection of a difference of 15% with 80% power and $P < 0.05$.

We used SPSS 15.0 (SPSS Inc., Chicago, IL) and STATA 7.0 (StataCorp LP, College Station, TX) for analysis. We analyzed the data on an intention-to-treat basis. We analyzed categorical data with Pearson chi-square tests, ordinal data with Mann-Whitney U tests, and continuous data with *t* tests. We assessed separately in each group the relation between the Cormack and Lehane grade with the number of intubation attempts, the time required to achieve ventilation, and the time required for the complete tracheal intubation process with the Spearman correlation. In the *LMA CTrach*™ group, we assessed the relation between the Cormack and Lehane grade and the success rate of viewing the glottis with the Spearman correlation. We considered correlation coefficients greater than 0.5 as clinically meaningful. Within each group, we compared the overall success of intubation in patients with Cormack and Lehane grades 1 and 2 and patients with grades 3 and 4 with chi-square tests.

Continuous data are presented as mean and SD. Ordinal data are presented as median and interquartile range. Categorical data are presented as number of patients, percentage, and 95% confidence interval of the percentage.

Results

Demographic data for the two study groups were similar (table 1). Tracheal intubation was successful on the first attempt in 93 of 137 patients (67.9%) in the *LMA Fastrach*™ group compared with 125 of 134 patients (93.3%) in the *LMA CTrach*™ group ($P < 0.001$). The overall success rates of tracheal intubation were 96.4% in the *LMA Fastrach*™ group and 100% in the *LMA CTrach*™ group ($P = 0.06$). Five patients in the *LMA Fastrach*™ group required tracheal intubation with the

Macintosh laryngoscope, after three failed attempts with the *LMA Fastrach*™. The time for the entire intubation procedure was significantly faster with the *LMA Fastrach*™ compared with the *LMA CTrach*™ (table 2). The success rates of ventilation and times to achieving ventilation were similar (table 2).

In the *LMA CTrach*™ group, the glottis was seen fully in 124 of 134 patients (92.5%). Tracheal intubation was successful on the first attempt in 120 of these 124 patients (96.8%). In the other 4 patients in whom the glottis was seen, the first attempts failed because of the endotracheal tube impinging on the arytenoids. Further manipulation was required, and the second attempts were successful. In 10 patients, the glottis was not visualized with the *LMA CTrach*™ despite multiple maneuvers, and blind intubation was performed. In only 5 of these 10 patients was blind tracheal intubation successful on the first attempt. In 3 patients, intubation was successful on the second attempt, and in 2 patients, intubation was successful on the third attempt.

In both the *LMA Fastrach*™ and *LMA CTrach*™ groups, there was no meaningful correlation between the Cormack and Lehane laryngoscopy grade and the number of intubation attempts, time to achieve ventilation, and time for tracheal intubation (table 3). In the *LMA CTrach*™ group, there was no meaningful correlation between the laryngoscopy grade and the success rate of viewing the glottis (table 3). In both groups, there was no difference in the overall success of tracheal intubation between patients with laryngoscopy grades 1 and 2 and those with grades 3 and 4. In the *LMA Fastrach*™ group, there was no difference between the four operators in the success of intubation on the first attempt and success within three attempts. In the *LMA CTrach*™ group, there was no difference between the operators in the success of intubation within three attempts. However, one operator had a lower first-attempt success rate.

Table 1. Demographic Data for the Study Groups

	<i>LMA Fastrach</i> ™, n = 137	<i>LMA CTrach</i> ™, n = 134	P Value
Age, yr	43.6 (14.1)	44.7 (13.8)	0.515
Sex, M/F, n (%)	52/85 (38.0/62.0)	51/83 (38.1/61.9)	0.543
Weight, kg	63.2 (13.5)	60.8 (11.5)	0.113
Height, m	1.62 (0.09)	1.62 (0.08)	0.778
Body mass index, kg/m ²	24.0 (4.3)	23.2 (3.6)	0.074
ASA physical status I/II/III, n (%)	93/34/10 (67.9/24.8/7.3)	82/48/4 (61.2/35.8/3.0)	0.414
Mallampati score 1/2/3/4, n (%)	78/37/19/3 (56.9/27.0/13.9/2.2)	84/34/15/1 (62.7/25.4/11.2/0.7)	0.273
Thyromental distance, cm	6.0 (1.0)	6.1 (1.0)	0.442
Mouth opening, cm	4.5 (0.9)	4.7 (0.9)	0.167
Neck circumference, cm	35.7 (4.5)	35.8 (3.2)	0.839
Cormack and Lehane grade 1/2/3/4, n (%)	83/48/5/1 (60.6/35.0/3.6/0.7)	79/42/13/0 (59.0/31.3/9.7/0.0)	0.677

Data are expressed as mean (SD) or number of patients (%). *P* values are from *t* tests for age, weight, height, body mass index, thyromental distance, mouth opening, and neck circumference; Mann-Whitney tests for American Society of Anesthesiologists (ASA) physical status, Mallampati score, and Cormack and Lehane grade; and chi-square test for sex.

Table 2. Success Rates and Times for Tracheal Intubation and Ventilation

	<i>LMA Fastrach</i> TM , n = 137	<i>LMA CTrach</i> TM , n = 134	P Value
Success of intubation on first attempt, n (%)	93 (67.9) [59.4–75.6]	125 (93.3) [87.6–96.9]	<0.001
Success of intubation within three attempts, n (%)	132 (96.4) [91.7–98.8]	134 (100) [97.3–100]	0.06
Median number of attempts to intubate, n (%)	1 (1–2)	1 (1–1)	<0.001
One/two/three attempts and failure at intubation, n (%)	93/29/10/5 (67.9/21.2/7.3/3.6)	125/7/2/0 (93.3/5.2/1.5/0.0)	NA
Time for complete tracheal intubation process, s	100 (74–121)	116 (82–156)	0.002
Success of ventilation with laryngeal mask conduit, n (%)	137 (100) [97.3–100]	134 (100) [97.3–100]	NA
Time to optimization of ventilation, s	23 (18–30)	25 (20–32)	0.077
Corrective maneuvers required to optimize ventilation, n (%)	86 (62.8) [54.1–70.9]	97 (72.4) [64.0–79.8]	0.094

Success rates are expressed as number (%) [95% confidence interval of percentage] and chi-square *P* value. Ordinal data are expressed as median (interquartile range) and Mann–Whitney *P* value.

NA = not applicable.

Discussion

We found a higher success rate of intubation on the first attempt with the *LMA CTrach*TM compared with the *LMA Fastrach*TM. Although the success rate within three attempts was higher with the *LMA CTrach*TM, this difference was not statistically significant. Optimizing placement and the view of the glottis with the *LMA CTrach*TM resulted in a longer time for tracheal intubation compared with the *LMA Fastrach*TM.

Possible limitations of our study are as follows. First, only 19 of the patients had Cormack and Lehane grade 3 or 4 laryngoscopy. The body mass index of our patients was normal, and there was a high proportion of female patients. These will limit the applicability of our findings, especially in heavier populations. Second, we did not use fiberoptic bronchoscopy to diagnose the causes of failed intubation attempts with the *LMA Fastrach*TM. Third, we used muscle relaxants in all patients. Although we checked that it was possible to ventilate the lungs with a facemask, we advise caution in using relaxants in patients with difficult airways. We used relaxants because they may reduce complications, particularly during insertion of the endotracheal tube and removal of the *LMA Fastrach*TM or *LMA CTrach*TM over the endotra-

cheal tube.¹⁵ Fourth, it was impossible to blind the investigators to the system they were using. Finally, although the investigators were experienced, they did not have completely uniform skill levels and success rates. We tried to minimize any confounding by using separate block randomization tables for each investigator.

The *LMA Fastrach*TM has an established role in difficult airway management, enabling ventilation and providing a conduit for tracheal intubation in situations where both mask ventilation and conventional tracheal intubation are difficult.^{3,5} In this study, there was no relation between the Cormack and Lehane grade and the time to achieve ventilation, tracheal intubation, and success of intubation with the *LMA Fastrach*TM or with the *LMA CTrach*TM. These success rates were achieved in both groups with the patients' heads and necks in a neutral posture and with minimal movement. Although the numbers of patients with difficult grades were small, our findings support their roles when intubation with conventional laryngoscopes is difficult.

In this study, more attempts at tracheal intubation were required with the *LMA Fastrach*TM compared with the *LMA CTrach*TM. Multiple blind attempts with the *LMA Fastrach*TM may traumatize the airway.¹⁶ Forceful

Table 3. Correlation with the Cormack and Lehane Laryngoscopy Grades in the *LMA Fastrach*TM and *LMA CTrach*TM Groups

	<i>LMA Fastrach</i> TM , n = 137	P Value	<i>LMA CTrach</i> TM , n = 134	P Value
Time to achieve ventilation	0.206	0.016	0.146	0.093
<i>LMA CTrach</i> TM success of viewing larynx	NA	NA	–0.179	0.038
Time to achieve <i>LMA CTrach</i> TM view of larynx	NA	NA	0.255	0.003
Number of intubation attempts	–0.018	0.833	0.097	0.267
Time for complete intubation process	0.227	0.008	0.308	<0.001

Correlations are expressed as Spearman rho coefficients.

NA = not applicable.

attempts may even cause arytenoid dislocation. Provided the larynx can be seen with the *LMA CTrach*™, the first-attempt intubation success rate is very high. Minor adjustments can be made while viewing the insertion of the endotracheal tube, to prevent impingement of the tube on the arytenoids or vocal cords. Although optimization of the *LMA CTrach*™ placement and view takes time, ventilation can be maintained throughout. The time taken for multiple failed *LMA Fastrach*™ attempts may also be substantial. However, when the *LMA Fastrach*™ and *LMA CTrach*™ are used as rescue devices, the success of ventilation is most important, and overall success of intubation may be more important than the success of intubation on the first attempt.

The incidence of epiglottic down-folding after *LMA Fastrach*™ insertion may be as high as 80%.¹⁷ The passage of the endotracheal tube through the *LMA Fastrach*™ lifts the epiglottis elevator bar, which in turn displaces the epiglottis. However, this may not correct epiglottic down-folding and the epiglottis can still obstruct passage of the endotracheal tube despite seemingly easy ventilation. Without fiberoptic bronchoscopic guidance, it is difficult to confirm and correct the cause of failed intubation. In this study, epiglottic down-folding was a common problem with the *LMA CTrach*™, and the *LMA CTrach*™ enabled visual confirmation of correction before tracheal intubation was attempted. Multiple up-down maneuvers were required in some patients, but ventilation was continued in between each maneuver.

Fiberoptic bronchoscopes and light wands have been used in combination with the *LMA Fastrach*™ to improve the success of tracheal intubation.^{18,19} The addition of a fiberoptic bronchoscope can improve the first-attempt success and reduce the risk of esophageal intubation and laryngeal trauma, but will add to the complexity of airway management. In comparison, the *LMA CTrach*™ system is completely portable, can easily be handled by a single operator, and requires less preparation time than a fiberoptic bronchoscope. These are significant advantages when working outside of the operating room.

The major limitation of the *LMA CTrach*™ is the failure to view the larynx in a noticeable proportion of patients despite multiple maneuvers. Even a small amount of secretions can completely obstruct any view. An innovative method of cleaning the fiberoptic tips with a swab inserted through the *LMA CTrach*™, without having to remove the *LMA CTrach*™ from the patient, may reduce the rate of failed views.²⁰ Second, the quality of the *LMA CTrach*™ fiberoptics deteriorates with repeated sterilization. In our experience, this was noticeable after 25 cycles. Although we were able to see the laryngeal anatomy clearly and found the *LMA CTrach*™ views adequate for guiding intubation, the image quality simply cannot match that of video laryngoscopes and fiberoptic

bronchoscopes. Third, although the *LMA CTrach*™ is cheaper than a fiberoptic bronchoscope, it is much more expensive than the *LMA Fastrach*™. A complete *LMA CTrach*™ set costs approximately US \$8,000 compared with US \$1,800 for an *LMA Fastrach*™ set in our country. With these disadvantages and the lack of a definitive difference in overall success of intubation in this study, the cost effectiveness of the *LMA CTrach*™ remains unclear despite its higher first-attempt intubation success rate.

Further study of the *LMA CTrach*™ specifically in patients with difficult airways is needed. A recent study found better oxygenation during intubation with the *LMA CTrach*™ compared with conventional laryngoscopy in morbidly obese patients.²¹ Future work could also compare the learning curves with the *LMA CTrach*™ and the *LMA Fastrach*™, and study how training with the *LMA CTrach*™ can improve skills with the *LMA Fastrach*™.

In conclusion, we found that the ability to optimize placement of the laryngeal mask conduit under vision with the *LMA CTrach*™ improved the success of tracheal intubation on the first attempt. However, it increased the time to achieve tracheal intubation, and laryngeal visualization failed in 7.5% of patients. The *LMA CTrach*™ concept of visualization is promising, and the *LMA CTrach*™ may have a role in difficult airway management, but we must moderate our expectations and its cost effectiveness is unclear.

The authors thank their anesthesiology colleagues and anesthesia nurses at the National University Hospital (Singapore) and KK Women's and Children's Hospital (Singapore) for their help and patience with this study.

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