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Comparative evaluation of Fastrach silicone wire-reinforced tube, polyvinyl chloride tube and PVC armoured tube for blind tracheal intubation through the intubating laryngeal mask airway

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ABSTRACT

Background and Aims: The reusable Fastrach silicone wire reinforced tube (FTST) was designed for tracheal intubation through the intubating laryngeal mask airway (ILMA). The polyvinyl chloride (PVC) tube and the PVC armoured tube (PAT) are disposable, cheaper and readily available as compared to the FTST. Hence, we decided to compare the clinical performance of these 3 types of tubes for tracheal intubation through the ILMA. **Methods:** Ninety patients between 18-65 years with ASA class I and II and Mallampati Grading I and II undergoing elective surgery under general anaesthesia were enrolled for this prospective, randomised study. Patients were divided randomly into three groups consisting of 30 patients each, to undergo intubation by FTST, PVC, PAT tubes through an ILMA. Overall success rate, ease of insertion, the number of attempts for successful intubation, critical incidence during intubation and post-operative sore throat were compared. Data was compiled and analysed using appropriate statistical tests and value of $p<0.05$ was considered significant. **Results:** The overall success rate was 100% in all groups; the first-attempt success rate was 90% with FTST compared to 83.33% with PVC and 60% with PAT. The time taken for intubation was 9.57±1.77 s in FTST group, 13.70±3.20 s in PVC and 15.13±2.94 s in PAT group. The incidence a of sore throat was 53.33% in PVC and 50% in PAT as compared with 26.66% in FTST group. **Conclusion:** The FTST is superior to PVC and PAT for intubation through an ILMA. PVC and PAT can be considered as an alternative to FTST in normal patients and their intubation success rates can be improved by using various manoeuvres for tube placement.

Key words: Fastrach silicon wire-reinforced tracheal tube, intubating laryngeal mask airway, polyvinyl chloride tracheal tube, PVC armoured tube

INTRODUCTION

Endotracheal intubation has been the standard practice of administering anaesthesia for most of the operations, which not only achieves a good control of airway but also facilitates ventilation, oxygenation and efficient delivery of anaesthetic gases into the trachea. Traditionally endotracheal intubation has always been achieved with the help of direct laryngoscopy which is associated with various shortcomings[1,2]. Thus, in order to overcome the various shortcomings of direct laryngoscopy Brain[4] designed and released in 1997-The Intubating LMA-Fastrach (ILMA), used as a ventilatory device and blind intubation guide[3–5]. The ILMA was designed as a conduit for tracheal intubation and to facilitate ventilation between attempts at tracheal intubation. The principal features of the ILMA are an anatomically curved, rigid airway tube with an integral guiding handle, an epiglottic elevating

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bar replacing the LMA bars, and a guiding ramp to direct the tracheal tube anteriorly as it emerges from the mask aperture[5–7].

The ILMA is indicated for routine, elective intubations but is especially useful for the unexpected difficult airway[8–10]. The tracheal tube originally designed for tracheal intubation through the ILMA is the Fastrach silicone wire reinforced tube (FTST) which is a straight, soft wire reinforced silicone tube with a full silicone distal inch terminating in a Tuohy-like tip. The FTST is a wire reinforced tube, is reusable but expensive and only limited sizes are available. Various workers have tried intubation with other tubes as an alternative to FTST like polyvinyl chloride tracheal tube (PVCT) and Latex armoured tube (LAT)[11,12]. The polyvinyl chloride tracheal tube (PVCT) and Latex armoured tube (LAT) are much less expensive, disposable, available in various sizes and readily available when required. It was observed in these studies that intubation in the first attempt was very low in PVCT (48%) and Parker tube (54%) as compared with the FTST.

The present study was planned to compare Fastrach silicone wire reinforced tube (FTST) with the polyvinyl chloride tracheal tube (PVCT) and PVC armoured tube (PAT) for blind tracheal intubation through the ILMA with respect to insertion success rate, time taken for insertion, number of attempts, manoeuvres required if any, ease of removal of ILMA, post operative airway morbidity and hemodynamic changes accompanying the insertion of the above tubes.

METHODS

Ninety patients between 18-65 years with ASA physical status class I and II and Mallampati grading I and II undergoing elective surgery under general anaesthesia were enrolled in this prospective, randomised study after obtaining approval of the college ethical committee. The study was conducted in our institute over a period of one year. Written informed consent was obtained from each patient. Patients were divided equally and randomly, according to computer-generated data, into three groups each consisting of 30 patients. In Group A patients, the Fastrach silicone wire-reinforced tracheal tube (FTST) was used for intubation through the Intubating LMA (ILMA), while in Group B patients, the polyvinyl chloride tracheal tubes (PVCT) were used for intubation through ILMA. In Group C patients, the PVC armoured tube (PAT) was used for intubation through ILMA.

Anaesthetic technique was same in all the three study groups. A study was conducted by the same team of anaesthesiologists who had expertise in the management of the airway. The following patients were excluded from the study: Patients with the inter-incisor gap <3 cm, thyromental distance <5 cm; patients with symptoms of upper respiratory infection in previous 10 days, patients with loose dentures, hypertrophied tonsils and thyroid enlargement, patients at risk of aspiration; patients with BMI >30 kgm^{-1}, patients with a previous history of difficult intubation, and patients with tumours, polyps and foreign body in the upper airway.

During the preoperative visit, demographic data like age, sex, weight and height was recorded and the basal metabolic index was calculated. Airway assessment was done and all relevant baseline investigations were checked. All the patients were prepared by overnight fasting and tab. midazolam 7.5 mg and tab rabeparazole 20 mg was given on the night before surgery.

In the operating room all the baseline parameters i.e. heart rate, ECG (lead II), blood pressure (systolic, diastolic, mean arterial pressure), and oxygen saturation were recorded on arrival followed by continuous monitoring of all these at regular intervals. Anaesthesia was induced with IV fentanyl 2 µg/kg followed by propofol 2-2.5 mg/kg and ondansetron 8 mg and neuromuscular blockade was achieved with rocuronium bromide 0.6 mg/kg in all patients. The patients were ventilated for 3 minutes and proper size ILMA was inserted based on the weight of the patient and the discretion of the expert anaesthesiologist using a single handed operator technique and cuff inflated with air. After connecting the Bain's circuit to the ILMA appropriate placement and ventilation was determined by chest wall movement, auscultation of breath sounds and a square wave capnograph trace. If any one of the criteria for satisfactory ventilation was not met, the ILMA was manipulated in situ by using the first step of Chandy's manoeuvre i.e. the ILMA being rotated in the sagittal plane until the least resistance to bag ventilation is achieved. All patients were ventilated through the ILMA with varying concentrations of isoflurane and N_2O in O_2 in the ratio of 66%:34%. Mechanical ventilation was continued till the end tidal carbon dioxide returned to 28-32 mmHg, and then blind intubation was attempted through the ILMA.

Based on the assigned group designated tracheal tube i.e. FTST, PVCT, or PAT of appropriate size 6.5 mm for ILMA no 3 and 7 mm for ILMA no 4 was selected. The designated endotracheal tube was inserted up to 15 cm with the curvature of the tube facing upwards. Intubation was considered successful if the tube passed beyond the 15 cm mark without any resistance. If the resistance was met while passing the tube various manoeuvres were tried i.e. the tracheal tube was rotated first clockwise. If resistance was still met then the tracheal tube was rotated counter-clockwise. If resistance was still met then it was moved up and down. Manoeuvres tried for tracheal placement of the tube were recorded on a three-point rank score: 0-Tracheal tube slides in freely without any manoeuvre, 1-Clockwise rotation of the tracheal tube, 2-Counter clockwise rotation of the tracheal tube, 3-Up and down movement of the tracheal tube.

Once the successful tracheal tube placement beyond the 15 cm mark was accomplished, the tracheal cuff was inflated, stabilized with silicone pusher and the ILMA was removed. The tube was connected to an anaesthetic circuit, tracheal intubation was confirmed by auscultation of the breath sounds and a square wave capnograph, and then the tube was fixed by taping it over the chin.

Heart rate and blood pressure were recorded before and 1 min after the insertion of ILMA, and 1, 3, 5 min after insertion of the tracheal tube. The time taken to intubate the trachea i.e. time from disconnection of breathing circuit of the ILMA to insertion of the silicone pusher was noted in each case. The record was made of the number of attempts to achieve successful intubation and the no of failed attempts at intubation. The time was taken to remove the ILMA i.e. time from insertion of the pusher to reconnection of breathing circuit to the tracheal tube was recorded. Any critical incident during ILMA removals such as accidental extubation or tube displacement was documented. The lowest oxygen saturation recorded during the procedure was also noted.

Two attempts were allowed before intubation was considered a failure. Intubation failure was defined as repeated tactile resistance was encountered during the passage of the tube, and the tube passed beyond 15 cm mark with no square wave capnograph trace (oesophageal intubation). When intubation was unsuccessful after two attempts, the procedure was abandoned. Tracheal intubation was then performed under direct laryngoscopy using PVC tube. Anaesthesia was maintained with $N_2O:O_2$ mixture in the ratio of 66%:34% with isoflurane in varying concentration (as required). Analgesia was provided by diclofenac 75 mg IV and rocuronium was used to maintain neuromuscular blockade as and when required. At the end of the surgery, neuromuscular blockade was reversed with neostigmine 50 µg/kg and glycopyrrolate 10 µg/kg and the endotracheal tube was removed once adequate spontaneous breathing effort was achieved. Any visible blood staining on the ILMA or the tracheal tube was noted at removal. Patients were enquired about any discomfort in the throat, sore throat, hoarseness and dysphonia in the postoperative period.

Data were analyzed using statistical package for the social sciences (SPSS) version 15.0 for Windows. All the data collected was compiled and analysed statistically using Chi-square test or ANOVA. The value of $p<0.05$ was considered significant.

RESULTS

There was no statistical difference among the three groups in terms of their age, sex, BMI, MPG, ASA status and the use of 1st and the 2nd step of Chandy's manoeuvre. (Table 1) Although the success rate of placement of ETT through ILMA was 100% with all types of tubes, but intubation using Fastrach silicone reinforced tube (FTST) through the ILMA was faster as compared to PVC and PAT (Table 2). Also with the FTST there was an ease of insertion, the removal time was less and the post operative sore throat was minimal as compared to the PVC and PAT. There was no statistically significant difference between the three groups in terms of various complications (Table 3). None of the patients desaturated during intubation, there was no episode of tube displacement or accidental extubation during the removal of the ILMA with the use of any of the tracheal tubes used in our study.

Table 1: Intergroup comparison of number of attempts to intubate in all three groups

Group	Number of patients	One	Two	Three	P-value
A	30	27 (90%)	2 (6.66%)	1 (3.33%)	0.233
B	30	25 (83.33%)	4 (13.33%)	1 (3.33%)	
C	30	18 (60%)	10 (33.3%)	2 (6.66%)	

Table 2: Time taken in seconds to intubate the trachea in all three groups

Group	Number of patients	Range (seconds)	Mean± SD (seconds)
A	30	7-14	9.57±1.77
B	30	10-25	13.70±2.94
C	30	11-23	15.13±2.94

Table 3: Comparison of complications at the end of procedure in all three groups

Group	Number of patients	Blood staining on ilma	Mouth, tongue or lip trauma	Sore throat	Hoarseness	Dysphonia
A	30	4 (13.33%)	4 (13.33%)	8 (26.66%)	0	0
B	30	5 (16.66%)	5 (16.66%)	16 (53.33%)	0	0
C	30	5 (16.66%)	5 (16.66%)	15 (50%)	0	0
P-value		0.919	0.919	0.076	1	1
Remarks			NS	NS	NS	NS

NS: Non significant.

DISCUSSION

Our study demonstrates that the intubation though the Intubating LMA was more successful with Fastrach silicone wire-reinforced tube (FTST) in the first attempt than polyvinyl chloride tracheal tube (PVCT) or PVC armoured tube (PAT) but the polyvinyl chloride tracheal tube (PVCT) and PVC armoured tube (PAT) were comparable to each other.

FTST tracheal intubation was successful in 100% patients, out of which 90% patients were intubated in the first attempt in our study. With PVCT, intubation was successful in 100% patients and 83.33% patients were intubated in the first attempt. With PAT, intubation was successful in 100% patients, with only 60% patients having intubation in the first attempt. Similar results were reported by Brain *et al.*[4,5] who showed 99% success rate of intubation on the first attempt with FTST. Kapila *et al.*[7] also showed 95% and 72 % success rate of intubation on the first attempt with the FTST and PVCT respectively. Kanazi *et al.*[11] reported the success rate of 90%, 54% and 48% after the first attempt of tracheal intubation via ILMA using the FTST, the posterior-beveled Parker tube, and the PVCT respectively.

The result of all the above studies was in accordance with our study that intubation through the Intubating LMA with the Fastrach silicone wire-reinforced tube has a higher success rate as compared to other tubes. In our study, the success rate of intubation on the first attempt with PVCT was much higher as compared to the studies done by Kapila *et al.*[7] and Kanazi *et al.*[11]. The reason could be that none of the workers in their studies have mentioned if any of the manoeuvres were used for tracheal placement of tube which has been used in our study. This could have led to the improvement in the success rate of intubation with polyvinyl chloride tracheal tube. Another reason for this higher success rate could be the expertise of anaesthesiologist.

None of the workers in any study compared the time taken and ease of removal of ILMA with various tubes. In our study, we observed that removal time of ILMA was faster with the FTST as compared to PVCT and PAT and the results were statistically significant. It was also observed that FTST causes lesser trauma to the airway.

The Intubation with FTST through ILMA was more frequently successful because the silicone wire-reinforced tube is a well designed, straight, soft, wire-reinforced silicone tube with a full silicone distal inch terminating in a conical Tuohy-like tip for use with the ILMA. The ILMA directs this flexible tube towards the plane of the glottis without distortion of the anatomy at an angle of 35 degrees. The FTST is firm enough to be directed anteriorly towards the glottis with a change in its angle of emergence when it strikes anywhere posterior to the glottis.

The conventional PVCT although is less expensive, readily available, and disposable but during insertion, it exits the Intubating LMA with an angle greater than 45 degrees. In addition, this tube is stiff, has a steep curvature and emerges from the ILMA with its distal end pointing too anteriorly to enter the glottis causing impingement of the tip of the endotracheal tube on the tubercle of the epiglottis, thus causing difficulty in passage of the tube through the glottis. Moreover, the polyvinyl chloride tube is unable to reverse its curvature from the plane of the inlet to pass into the trachea because of the additional curvatures imposed on it by the metal shaft of the ILMA.

Joo and Rose[13] recommended backward insertion of the PVCT into ILMA such that the concave bend faces down, though we did not use this in our study. This technique allows the tube to follow a more anatomical direction compared with conventional insertion and improves the success rate of intubation.

The PAT, on the other hand, is extremely soft and wire-reinforced to its bevel, unlike the FTST which has a full silicone distal inch. The pressure exerted by the epiglottis-elevating bar on the distal end of the PAT directs it more posteriorly, and it emerges at an angle of 30° from the distal aperture of the ILMA. Consequently, when mild force is applied on encountering resistance during tracheal intubation, it tends to buckle and bulges upward with the tip pointing downward, without the change in the angle of emergence. Thus, a downward and posterior orientation of the tracheal tube is attained, making it more vulnerable to slip into the oesophagus. These factors attribute to the repeated attempts and manoeuvres required for intubation with PVCT and PAT.

The study conducted by Kundra *et al.*[12] demonstrated an overall success rate with PVCT similar to that with the FTST (96%); in addition, the first-attempt success rate was similar with both tracheal tubes (86%).These findings were different from the findings of our study. The principal cause of different findings in our study was that PVCT in their study was being prewarmed up to 40 °C before intubation as prewarming the PVCT to 40 °C causes softening of the tube leading to a higher success rate of intubation. In our study, we did not prewarm the PVCT and hence the tube was stiffer.

In our study, the sore throat was found to be a more common complaint with PVCT (53.33%) and PAT (50%) as compared to FTST (26.66%). Lu *et al.*[16], Kundra *et al.*[12] and Ye *et al.*[14] also reported that the incidence of a sore throat was more with conventional PVCT. The PVCT is unable to reverse its curvature from the plane of the inlet to pass into the trachea because of the additional curvatures imposed on it by the metal shaft of the ILMA. As a result, the tip of the tube may push against the anterior portion of the glottis and vocal cords, which can cause trauma and increased the incidence of a sore throat with PVCT. Joo *et al.*[15] examined the maximal in vitro forces and pressures exerted by the tip of various tracheal tubes as they exit the ILMA and found that the PVCT exerted 7–10 times higher forces and pressures than the silicone and armoured endotracheal tubes. This could contribute to increased morbidity to a patient's airway and esophagus. Therefore, caution must be used with the passage of the PVC tube through the ILMA and the use of force must be avoided to prevent airway trauma. A drawback of our study is the lack of blinding because it was impractical to conceal the tubes during insertion through the ILMA. A good mask-larynx relationship was ascertained clinically rather than with a fiberoptic view because its availability was not always guaranteed.

CONCLUSION

The Fastrach silicone wire reinforced tube (FTST) is superior to polyvinyl chloride tube (PVCT) and PVC armoured tube (PAT) for intubating through an Intubating laryngeal mask airway (ILMA), with respect to insertion success rate, the time taken for intubation, time taken for the removal of ILMA and postoperative airway morbidity. PVC and PAT can be considered as alternatives to FTST and their intubation success rates can be improved by various ways like using various manoeuvres for tube placement.

COMPETING INTERESTS

None declared.

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