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Comparison of the effectiveness of endotracheal tube holder with the conventional method in a manikin model

Karn Suttapanit, Chaiyaporn Yuksen*, Kasamon Aramvanitch, Thitapohn Meemongkol, Arnon Chandech, Benjamat Songkathee, Promphet Nuanprom

Department of Emergency Medicine, Mahidol University, Bangkok, Thailand

*Corresponding author

Abstract:

OBJECTIVES: Endotracheal tube (ETT) displacement occurs by improper fixation. To fix an ETT, many types of fixation tools are employed. Thomas tube holder is one of the fixation tools widely used in many countries. This study aims to compare the ETT fixation using the Thomas tube holder with the conventional method (adhesive tape) in a mannequin model.

METHODS: The fixation tools were random, using the box of six randomizes to Thomas tube holder and conventional method. After fixation, the mannequin model was being logged roll, chest compression by automated chest compression machine, and transported by the paramedic. The time to ETT fixation and displacements were recorded.

RESULTS: The mean time (standard deviation) to fixate an ETT was shorter (33.0 s [7.3]) with a Thomas tube holder compared to adhesive tape (52.6 s [7.3], $P < 0.001$). The number and proportion of the ETT displacements were significantly less with Thomas tube holder compared to adhesive tape during log roll (16, 35.6% vs. 29, 64.4%, $P = 0.011$), chest compression with automated machine (23, 51.1% vs. 37, 82.2%, $P = 0.003$), and transport (26, 57.8% vs. 40, 88.9%, $P = 0.002$).

CONCLUSION: The Thomas tube holder is more effective than adhesive tape in preventing ETT displacement in a mannequin subjected to log roll, chest compressions, and transportation.

Keywords:

Adhesive tape, endotracheal tube displacement, Thomas tube holder

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ORCID:

KS: 0000-0002-7533-6663

CY: 0000-0002-4890-7176

KA: 0000-0002-5995-3370

TM: 0000-0003-3012-8227

AC: 0000-0002-5552-2442

BS: 0000-0003-0474-6355

PN: 0000-0001-7523-8353

Address for correspondence:

Dr. Chaiyaporn Yuksen,
270 Rama Vi Road, Thung
Phaya Thai, Ratchathewi,
Bangkok 10400, Thailand.

E-mail: chaipool0634@
hotmail.com

Introduction

Endotracheal (ET) tube intubation is an invasive emergency procedure in prehospital care. The complications from ET intubation should be monitored. The most common complications include perforation of the trachea, spontaneous pneumothorax, or aspiration pneumonia. The complications can come from many

factors, including the procedure to open the airway, intubation, and the displacement of the ET tube after the fixation.^[1-3] Displacement of the ET tube might occur after the ET tube intubation, which might occur from the recovery of the patient, restlessness of the patient, movement of the patient, or a poor fixation quality that can cause the patient to choke and cause injury at the trachea, which can lead to aspiration pneumonia.^[4-6]

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Box-ED**What is already known on the study topic?**

For prehospitalization care, endotracheal tube fixation is accomplished with adhesive tape and a Thomas tube holder. The endotracheal tube can become displaced as a result of improper fixation material.

In the setting of CPR or during lifting and moving, the endotracheal tube may become displaced.

What was the conflict? Is it important for readers?

The effectiveness of endotracheal tube fixation with the Thomas tube holder and conventional method (adhesive tape) was controversial.

The Thomas tube holder was more expensive than the conventional method (adhesive tape).

How was this study structured?

Endotracheal tube fixation with the Thomas tube holder was compared with fixation by the conventional method (adhesive tape) with the use of a mannequin model that was subjected to log rolls, chest compressions by an automated machine, and transportation to many places 90 times.

What does this study tell us?

The Thomas tube holder is more effective than adhesive tape in preventing ET tube displacement in a mannequin subjected to log roll, chest compressions, and transportation.

The ET tube fixation is considered to be the last process of ET intubation. The fixation of the ET tube after examination of the position of the ET tube is an important procedure. Fixation with poor quality materials might cause the ET tube to be displaced from a suitable position and affect the patient, such as choking and pneumonitis.^[6] The material for the fixation of ET tube is polymer, which has surface tension. When contacting with the secretion of the patient, it might cause displacement. The fixation of ET tube by using the Thomas tube holder is widely popular.^[7] However, in Asian countries, Thomas tube holder is not commonly used.^[8,9]

In the setting of prehospital care, the ET intubation patients need to move with log roll procedure, chest compression, lifting, and moving on route to the hospital. These procedures increase the probability of ET tube displacement. This study aims to compare the ET tube fixation using the Thomas tube holder with the conventional method (adhesive tape) in a mannequin model with log roll procedure, chest compression with automated chest compressor machine, lifting, and moving on route to the hospital.

Methods

Study design and setting

This was a randomized prospective comparative study.

We used mannequins to compare the time for insertion and the displacement from the normal fixation of the ET tube.

Sample size estimation

Wagne *et al.* conducted research on fixing ET tubes, in the United States of America in 2016, comparing 7 fixation methods.^[10] These included the Lillehei Method, the Clove Hitch Knot, the Thomas Tube Holder, the Solod AiRity, and the Anchor Fast. The study sample size was estimated by using the data from research on the fixation of ET tubes in a population of 30 persons for a two-sample comparison of proportions. The displacement with normal fixation was 97% and the use of the Tube holder was 3%. Power was 0.9, the ratio of sample size 1:3, $P = 0.05$, and the two-sided test found that the minimum sample size was 88 persons.

Methods and measurements

We included 6 participants from paramedics who provided signed consent to participate in the research. We divided the types of fixation of the ET tube into two groups, Type 1 was a normal fixation with adhesive tape and Type 2 was the Thomas tube holder. The adhesive tape was Fixomull Stretch tape (BSN Medical, Hamburg, Germany) 2-cm wide and 20 cm in length [Figure 1]. The ET tube holder was a Thomas tube holder product [Figure 2]. The ET tube was intubated by the researcher. We used a No. 7.5 ET tube, and the fixation distance was 21 cm. The distance that the ET tube was displaced from the fixation mark at 21 cm was defined as ET tube displacement, and the distance of displacement was recorded.

We used Sequential Numbered, Opaque, Sealed Envelopes, and a block of six randomization numbers. The position and responsibilities of the participants were as follows: Person 1 was positioned at the head of the mannequin to squeezing the reservoir bag. Persons 2, 3,

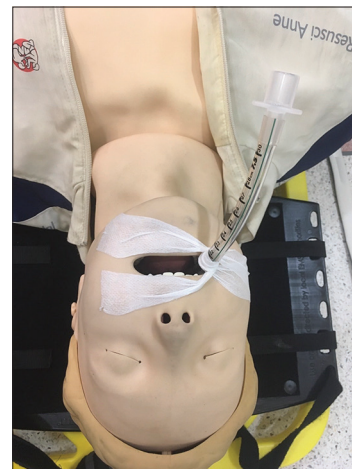


Figure 1: Normal fixation with adhesive tape



Figure 2: Endotracheal tube holder (Thomas tube holder)

4, and 5 were positioned at each side of the mannikin, level with the shoulders and thighs of the mannequin, which was on a spinal board, ready to be moved. Person 6 fixed the already inserted ET tube using the method assigned by randomization.

An opaque black cloth was then used to cover the face of mannequin so that Persons 1, 2, 3, 4, and 5 would not see the type of fixation used for the mannequin [Figure 3]. When the mannequin was ready, Person 1 connected the bag valve mask to the ET tube. Persons 2, 3, and 4 turned the patient onto the side using the log roll method. Person 5 put the long spinal board with three standard straps in place. The researcher recorded the degree of displacement of the ET tube (without letting the supportive team know the fixation method). The supportive team set up the automated chest compressor machine on the mannequin, while Person 1 supported the breathing by squeezing the reservoir bag until completing 2 min and recorded the displacement of the trachea tube.

Then the mannequin was moved with Person 1, giving the signal to lift up the spinal board. Then, the patient was moved (down the stairs one level and down another level by elevator, then up the stairs one level and up another level by elevator). Then the mannequin was brought back to the original location and position. The total distance taken during the transportation of the patient was 350 m and we moved the mannequin totally 90 times. Displacement or slipping of the ET tube in each moving was monitored, and the results were recorded.

Statistical analysis

The Chi-square and Fisher's exact tests for categorical data were used to find statistically significant differences. The comparison of data was made using McNemar's test for the paired nominal data variables. The *t*-test of rank-sum tests were used for the comparison of



Figure 3: An opaque black cloth covers the face of a mannequin

continuous data. The statistical data were analyzed using STATA version 14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). Sample size estimation was performed using STAT version 12 (StataCorp. 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP). The maximum type I error accepted for this study was 5%. This study was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Thailand (MURA2017/883).

Results

The mean time to fixate an ET tube with the Thomas tube holder took statistically significantly less time than using adhesive tape, 33.0 s (standard deviation [SD]: 7.3) versus 52.6 s (SD: 7.0), respectively, as shown in Table.

After moving the mannequin onto their side with the log roll method, the proportion of ET tube displacement was significantly less frequent with the Thomas tube holder ($n = 16/45$, 35.6%) compared to using adhesive tape ($n = 29/45$, 64.4%, $P = 0.011$). The mean (SD) displacement distance of the fixation with Thomas tube holder was 1.1 mm (0.3) compared to 1.4 mm (0.6) with adhesive tape, but the difference in was not statistically significant, as shown in Table ($P = 0.096$).

After performing chest compressions using the automated chest compressor machine, the proportion of ET tube displacement was significantly less frequent with the Thomas tube holder ($n = 23/45$, 51.1%) compared to using adhesive tape ($n = 37/45$, 82.2%, $P = 0.003$). The mean (SD) displacement distance of the fixation with Thomas tube holder was 1.2 mm (0.4) compared to 1.6 mm (0.8) with adhesive tape, but the difference in was not statistically significant, as shown in Table ($P = 0.051$).

After moving mannequin, the proportion of ET tube displacement was significantly less frequent with the Thomas tube holder ($n = 26/45$, 57.8%) compared to using adhesive tape ($n = 40/45$, 88.9%, $P = 0.002$). The mean (SD) displacement distance of the fixation with Thomas tube holder was 1.2 mm (0.4) compared to 1.4 mm (0.5) with adhesive tape, but the difference in was not statistically significant, as shown in Table ($P = 0.203$).

Discussion

The ET tube should be fixed using adhesive tape or commercial fixation tools.^[11] Currently, ET tubes are fixed in a variety of ways, for example, adhesive tape, string, and commercial fixation devices. Researchers and experts have noted the importance of using the safest tools to fix the ET tube.^[7-9,12-16] The Thomas tube holder was superior to adhesive tape in securing the ET tube in a mannequin to log roll, chest compressions, and transportation.

The time it took for the Thomas tube holder to establish ET tube fixation was significantly shorter than that with adhesive tape. In emergency situations such as prehospitalization trauma care, cardiac arrest, and mass casualty incidents, the fastest fixation technique enables the fastest evacuation.^[17]

ET tube displacement of more than 1 cm was defined as clinically significant, and displacement of >4 cm was considered to confer high risk for extubation.^[18] Many previous studies were performed on simulation mannequins to determine the force required to displace an ET tube displacement, and the Thomas tube holder secured the ET tube better than did adhesive tape.^[10,19] In this study, clinically significant displacement of the ET tube (>1 cm) occurred with both the Thomas tube holder and adhesive tape, but the displacement was

not considered to confer a high risk for extubation (>4 cm) in log rolling, chest compression, lifting, and moving.

In previous studies of other new commercially available Thomas tube holders in the prehospitalization setting and operation room, the Haider Tube-Guard (Haider Scientific, San Diego, CA, USA),^[20] the Shiley™ Evac Endotracheal Tube with TaperGuard™ Cuff (Medtronic, Dublin, Ireland),^[21] the Thomas tube holder,^[10,19] and the AnchorFast Oral Endotracheal Tube Fastener (Hollister, Libertyville, IL, USA) have significantly reduced the displacement of the ET tube in comparison with adhesive tape and reduces the rate of lip ulcers and facial skin tears.^[22]

In the prehospitalization setting, emergency situations such as cardiac arrest can occur. Automatic chest compression is the standard treatment during transportation.^[23] In the prehospitalization setting, the time to ET tube intubation and fixation must be minimized. The incidence of ET tube displacement during automatic chest compressions should be reduced with the use of the Thomas tube holder. Patients in cardiac arrest need to be log rolled, moved onto the backboard, and transported to the ambulance. The incidence of ET tube displacement after rolling the body using the log roll method or after repeatedly moving the patient by using the Thomas tube holder was also less than with fixation using adhesive tape, with statistical significance.

The Thomas tube holder is more expensive than adhesive tape. Adhesive tape allows more displacement of the ET tube than does the Thomas tube holder, but the displacement does not exceed 4 cm (which confers high risk for extubation). The difference between ET tube displacements caused by the two methods was statistically significant but not clinically significant. Only 1-to 2-mm displacement of the ET tube does not cause serious problems.

Limitations

There were some limitations to our study. First, our data came from a single center. Second, the results obtained with the mannequin model in this study may not apply in real clinical situations in the prehospitalization setting, but we tested the methods with the actions used in prehospitalization settings: Log roll, chest compression, lifting, and moving.

Conclusion

The Thomas tube holder is more effective than adhesive tape in preventing ET tube displacement in a mannequin subjected to log roll, chest compressions, and transportation.

Table: Comparison of Adhesive Tape and Thomas Tube Holder

| | Adhesive tape (n=45) | Thomas tube holder (n=45) | P |
|---------------------------------------|----------------------|---------------------------|--------|
| Time to fixation, mean (SD) | 52.6±7.0 | 33.0±7.3 | <0.001 |
| Incidence of tube displacement, n (%) | | | |
| Log Roll | 29 (64.4) | 29 (64.4) | 0.011* |
| Automated chest compressions | 37 (82.2) | 23 (51.1) | 0.003* |
| Patient was moved | 40 (88.9) | 26 (57.8) | 0.002* |
| Displacement distance (mm), mean (SD) | | | |
| Log Roll | 1.4 (0.6) | 1.1 (0.3) | 0.096 |
| Automated chest compressions | 1.6 (0.8) | 1.2 (0.4) | 0.051 |
| Patient was moved | 1.4 (0.5) | 1.2 (0.4) | 0.203 |

*Statistically significant with a $P < 0.05$

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Author contribution statement

KS and CY conceived and designed the experiments, and defined the intellectual content; TM and AC performed the literature search, KA, TM, AC, BS and PN performed the experiments; AC, BS and PN acquired the data and analyzed the data; CY and KA performed the statistical analysis and interpreted the data; CY and KS drafted the manuscript. All authors reviewed and confirmed the final draft of the manuscript.

Conflicts of interest

None Declared.

Ethical approval

This study was approved by the committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Thailand (MURA2017/883).

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