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Brief Reports

SHIFTS IN ENDOTRACHEAL TUBE POSITION DUE TO CHEST COMPRESSIONS: A SIMULATION COMPARISON BY FIXATION METHOD

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☐ **Abstract—Background: Endotracheal tube placement during resuscitation is important for definite tracheal protection. Accidental extubation due to endotracheal tube displacement is a rare event that can result in severe complications. Objective: This study evaluated how endotracheal tube displacement is affected by tape vs. tube holder fixation using a manikin and auto-chest compression machine simulation. Methods: The endotracheal tube was placed in either a shallow or a deep position, with the tube cuff at the center of the glottis or 26 cm from the incisors in an advanced life-saving simulator. Trials were performed five times in each setting with: no fixation; Durapore® tape fixation; Multipore® tape fixation; and Thomas tube holder® fixation. After 10 min of automated chest compressions, endotracheal tube shift was measured. Statistical analysis was performed with one-way repeated analysis of variance or χ^2 test, with $p < 0.05$ considered significant. Results: In the shallow setting, endotracheal tube extubation occurred in all trials with no fixation, Durapore, and Multipore. In contrast, no extubation occurred in the Tube holder trials ($p < 0.05$). In the deep setting, no extubation was confirmed in any trial. Relative to no fixation (0.56 ± 0.11 cm), endotracheal tube shift was significantly less in the Durapore tape, Multipore tape, and Tube holder groups ($p < 0.05$). Of the three fixation methods, Tube holder (0.04 ± 0.05 cm) showed significantly less shift ($p < 0.05$) relative to Durapore (0.28 ± 0.04 cm) and Multipore (0.32 ± 0.08 cm). Conclusion: Endotracheal tube displacement occurs less with Tube holder fixation than with Durapore tape or Multipore tape during simulation of continuous chest compressions.** © 2015 Elsevier Inc.

☐ **Keywords—endotracheal tube; position shift; chest compression; tape fixation; tube fixation; simulation**

INTRODUCTION

The 2010 European Resuscitation Council (ERC) cardiopulmonary resuscitation (CPR) guidelines emphasize the importance of minimizing interruptions in chest compressions to maximize coronary and cerebral perfusion pressure (1). Once endotracheal intubation is completed, rescuers can perform continuous chest compressions due to the definite separation and protection of the trachea from the esophagus and stomach (2). Definite endotracheal intubation can also prevent stomach expansion due to bag-valve-mask or supraglottic device ventilation leading to vomitus aspiration. Quality of chest compressions can be measured by the end-tidal CO_2.

After successful endotracheal intubation, the endotracheal tube must be secured to prevent movements of the tube that may result in extubation (3). Unplanned extubation has been reported in many patients in the context of critical care, but very little research has examined the frequency of this in the emergency department or in the context of resuscitation (4–6). Activities that involve patient movement are known to increase the risk of unintentional extubation, and it seems likely that

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patients intubated during chest compressions exhibit a high risk of accidental extubation.

The present study evaluated the effect of various fixation methods on endotracheal tube displacement in a manikin and auto-chest compression machine model. Specifically, we compared adhesive extensive tape, nonextensive tape, and tube holder fixation, with no fixation set as a control.

We hypothesized that the endotracheal tube would shift with continuous chest compressions, and that fixation method would affect this shift. Because a clinical evaluation of such fixation during resuscitation is unethical, we decided to use a manikin and automated chest compressor to compare fixation methods used to prevent endotracheal tube shift during chest compressions.

MATERIALS AND METHODS

The ALS [advanced life saving] Simulator® manikin (Laerdal, Stavanger, Norway), which was designed to represent the anatomy of a male adult, was used for the endotracheal tube placement and continuous chest compressions. The internal diameter of the endotracheal tube (Portex, St. Paul, MN) was 7.5 mm. Under observation of videolaryngoscope Pentax-AWS Airwayscope (Hoya, Tokyo, Japan), we placed the endotracheal tube in a shallow or in a deep position, with the tube cuff either at the center of the glottis or 26 cm from the incisors in the ALS Simulator. After endotracheal tube placement, we inserted 5 mL of air into the cuff.

Figure 1 shows the fixation methods after endotracheal tube placement. We compared four fixation methods: no fixation (Figure 1A); adhesive nonextensive tape Durapore® (3M Company, St. Paul MN) tape fixation (Figure 1B); adhesive extensive tape Multipore® (3M Company) tape fixation (Figure 1C); and Thomas Tube Holder® (Tube holder; Laerdal) fixation (Figure 1D). Next, 10 min of continuous chest compressions were performed by the same automated chest compressor (LUCAS2, Physio-Control, Washington, DC) according to the 2010 ERC guidelines (2). After 10 min of automated chest compressions, the simulator was checked for endotracheal tube extubation as well as the distance the tube had moved, measured at the incisors. Extubation was defined as "separation of endotracheal tube from the glottis" and was confirmed by monitoring with the Pentax-AWS Airwayscope simulator. Trials were performed five times in each setting. The entire experimental process was conducted by the authors.

Differences in the distance the endotracheal tube had shifted in the different settings were analyzed by one-way repeated-measures analysis of variance followed by Tukey's multiple comparisons. The χ^2 test was used to compare the incidence of tube extubation after continuous chest compressions. Results are expressed as mean ± SD, with $p < 0.05$ considered statistically significant.

RESULTS

Rate of Extubation after 10 Min of Chest Compressions

In the shallow setting, all trials with no fixation, Durapore tape, or Multipore tape fixation showed endotracheal tube extubation within 10 min. In contrast, no extubation occurred in the Tube holder trials ($p < 0.05$). In the deep setting, no extubation was confirmed in any trial after 10 min of chest compressions.

Endotracheal Tube Shift after 10 Min of Chest Compressions

The endotracheal tube shift after 10 min of chest compressions is shown in Figure 2. Relative to that with no fixation, endotracheal tube shift in the deep setting was significantly less with Durapore tape fixation, Multipore tape fixation, and Tube holder ($p < 0.05$). Among the three fixation methods, Tube holder showed significantly less shift relative to Durapore and Multipore ($p < 0.05$) (No fixation, 0.56 ± 0.11 cm; Durapore, 0.28 ± 0.04 cm; Multipore, 0.32 ± 0.08 cm; Tube holder, 0.04 ± 0.05 cm) (Figure 2).

DISCUSSION

Airway management is considered an important element for in-hospital CPR. Current ERC guidelines emphasize the importance of the delivery of continuous chest compressions with as few interruptions as possible, including pauses for airway management (1,2). After endotracheal intubation confirmation, the need for endotracheal tube stabilization is critical, and many studies have found that endotracheal tube holding during resuscitation, through the use of a tube holder or wire anchoring to the oral cavity, can reduce the incidence of unplanned extubation (7–9). Our study found that chest compressions were associated with outward displacement of the endotracheal tube.

Our results showed that all trials with no fixation, Durapore tape, or Multipore tape fixation showed endotracheal tube extubation within 10 min in the shallow setting. Furthermore, in the deep setting, about 0.5-cm tube displacement occurred with no fixation, and about 0.3-cm migration was seen even with Durapore or Multipore fixation. These results clearly indicate that endotracheal tube shift occurs during chest compressions, leading to accidental extubation. One possible reason for this may be the repetitive intratracheal pressure caused by chest compressions. A continuous air stream