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Simulation and education

Bystander cricothyroidotomy with household devices – A fresh cadaveric feasibility study☆

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ABSTRACT

Introduction: In various motion pictures, medical TV shows and internet chatrooms, non-medical devices were presented as tools for life-saving cricothyroidotomies. However, there is uncertainty about whether it is possible for a bystander to perform a cricothyroidotomy and maintain gas exchange using improvised household items. This study examines the ability of bystanders to carry out an emergency cricothyroidotomy in fresh human cadavers using only a pocket knife and a ballpoint pen.
Materials and methods: Two commonly available pens and five different pocket knives were used. Ten participants with no or only basic anatomical knowledge had to choose one of the pens and one of the knives and were asked to perform a cricothyroidotomy as quickly as possible after a short introduction. Primary successful outcome was a correct placement of the pen barrel and was determined by the thoracic lifting in a mouth-to-pen resuscitation.
Results: Eight (80%) participants performed a successful approach to the upper airway with a thoracic lifting at the end. Five participants performed a cricothyroidotomy and three performed an unintentional tracheotomy. Injuries to muscles and cartilage were common, but no major vascular damage was seen in the post-procedural autopsy. However, mean time in the successful group was 243 s.
Conclusion: In this cadaveric model, bystanders with variable medical knowledge were able to establish an emergency cricothyroidotomy in 80% of the cases only using a pocketknife and a ballpoint pen. No major complications (particularly injuries of arterial blood vessels or the oesophagus) occurred. Although a pocket knife and ballpoint pen cricothyroidotomy seem a very extreme procedure for a bystander, the results of our study suggest that it is a feasible option in an extreme scenario. For a better outcome, the anatomical landmarks of the neck and the incision techniques should be taught in emergency courses.

Introduction

Acute airway obstruction is a rare but potentially life-threatening situation. If neither an intubation nor a mask or mouth-to-mouth ventilation is possible a cricothyroidotomy may be necessary. Paix et al. describe 24 prehospital cases where a cricothyroidotomy was performed as a primary procedure either because of anatomical injury or lack of access to the airway in an entrapped patient.[1] Even in a pre-hospital arena, cricothyroidotomy requires equipment and a certain medical expertise. There exist commercially available cricothyroidotomy sets (i.e. Quicktrach®) with included tracheostomy cannulas and sharp incision trocars. But, in the prehospital setting, the medical equipment required to perform this procedure may not be readily available to bystanders and nonmedical objects may need to be adapted in order to perform this procedure. There is a paucity of literature examining surgical cricothyroidotomy in the emergency setting[2,3] and only one case report describes the use of improvised non-medical equipment.[4]

In various motion pictures (i.e. "SAW V", the german "Tatort"), medical TV shows ("Dr. House: Twenty Vicodin, Season 8, film 1") and internet chatrooms, ballpoint pens and knifes were presented as tools for a life-saving cricothyroidotomy. Even some medical and survival training books recommend a knife for the incision and the barrel of a ballpoint pen as a cannula.[5–7]

Platt-Mills et al. report in their cadaveric study in fresh cadavers a method of improvised cricothyroidotomy using the spike of a

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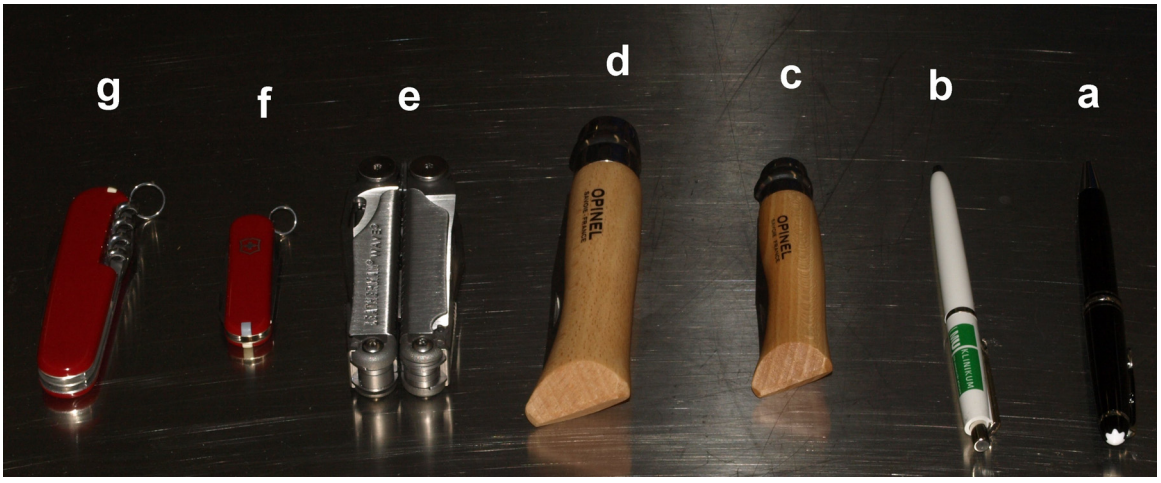

Fig. 1. Non-medical devices used in this study for an invasive airway management.

high-flow intravenous spike and drip chamber.[8] Neill and Anderson performed a study with nine junior doctors and medical students, who were able to place a successful cricothyroidotomy just with a ballpoint pen and a scalpel blade in fourteen formalin-fixated cadavers.[9] In a previous study of our working group we could show that a cricothyroidotomy in fresh cadavers just with a ballpoint pen is nearly impossible.[10]

However, there is uncertainty about whether it is possible to perform a cricothyroidotomy and maintain gas exchange using improvised non-medical devices. This study examines the ability of bystanders to place an emergency cricothyroidotomy in fresh human cadavers using only a pocket knife and a ballpoint pen.

Materials and methods

Procedures were performed on unselected, undissected fresh human cadavers from the forensic department of the University of Munich. No cadaver was older than two days. All cadavers were cooled to 8 °C (not frozen) and allowed to warm to room temperature before incision. The study was approved by the local ethical review committee under the N°336-13. The relatives of the recently deceased persons received information about the study and were asked for permission by the forensic department. Informed consent was given in all cases on the basis of the known or presumed will of the deceased. The complete cricothyroidotomy was recorded by video.

Only few ballpoint pen barrels meet the criteria for cricothyroidotomy tubes.[11] In a previous study the following two commonly available ballpoint pens were selected[10]:

- The Montblanc Masterpiece Platinum Line Classique made of black ebony with a removable metal jacket at the top. Despite the high price one of Montblanc's bestsellers worldwide (Fig. 1a).
- The Ritter-Pen 01711 Classic made of opaque plastic with a removable metal jacket at the top (Fig. 1b).

A variety of knives were available for the participants to choose freely. Skin cutting is depended on the force applied and the sharpness and length of the blade (b_l). From S. V. Hainsworth, R. J. Delaney and G. N. Rutty[19] it is known that the blunt edge radius (b_r) of a knife is most important for the penetration ability in stab injuries (Fig. 3). All knives are well-known and are distributed all over the world:

- Victorinox 1.3603 Spartan red, b_r = 0.028 mm, b_l = 5.0 cm (Fig. 1g)
- Victorinox 0.6385 MiniChamp red, b_r = 0.020 mm, b_l = 3.5 cm (Fig. 1f)
- Leatherman Wave, b_r = 0.024 mm, b_l = 6.0 cm (Fig. 1e)
- Opinel N°7 stainless, b_r = 0.032 mm, b_l = 10.0 cm (Fig. 1d)
- Opinel N°5 stainless, b_r = 0.024 mm, b_l = 5.0 cm (Fig. 1c)

Participants of the study included 3 medical students and 1 dentistry student in their first or second preclinical year. While all of these students had anatomical training, none had experience in surgery, surgical procedures or emergency medicine. The other six participants were medical laypersons (e.g., police officer, teacher, flight attendant).

Cadavers were placed supine with their neck exposed. Before the beginning of the experimental procedure the thyroid cartilage was tested to be clearly palpable in all cadavers by the supervisors of the forensic institute (A. Huber and Ch. Braun). All participants received a 2 min scenario informing them of an emergency situation with an unconscious person with no success of mouth-to-mouth-resuscitation. They had to choose one of the pens and one of the knives and were asked to access the upper airway with these devices to establish a mouth-to-pen-resuscitation as fast as possible. They were advised to identify the thyroid cartilage as a possible landmark. No information was given concerning the exact location to start the procedure. Procedure time was defined as the time from when the participant touched one of the non-medical devices until they were happy with the placement of the pen barrel or the participant abandoned the procedure.

The primary outcome of the study was the rate of successful placement of the pen barrel within the trachea and was determined at the end by the thoracic lifting in a mouth-to-pen resuscitation. Secondary outcomes were injuries to associated anatomical structures and time to placement. The collateral damage was determined afterwards by professional preparation of the cervical structures, done by the forensic institute.

Results

The main results are summarized in Table 1.

Bystanders were an average age of 31.8 y (SD = 7.3 y), and 8 of 10 were women. Cadavers were an average age of 74 (SD = 7.8 y) years at death, the gender distribution was 50/50 and the average body mass index was 26.4 kg/m^2, whereas the neck length in average was 6.75 cm (SD = 1.339 cm). The thyroid cartilage was palpable by the supervisors in all cadavers. Eight out of ten (80%) participants performed a successful approach to the upper airway with a thoracic lifting in the mouth-to-pen resuscitation. Five participants performed a successful cricothyroidotomy and three performed an unintentional tracheostomy, but with a positive