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CLINICAL PAPER

Advanced cardiac life support before and after tracheal intubation—direct measurements of quality☆,☆☆

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KEYWORDS
Out-of-hospital CPR;
Orotracheal intubation;
Ventilation;
Transthoracic impedance;
Chest compression

Summary
Study hypothesis: Tracheal intubation should improve the quality of cardiopulmonary resuscitation (CPR) by enabling adequate ventilation without pauses in external chest compressions.
Methods: Out-of-hospital cardiac arrests of all causes were sampled in this non-randomized, observational study of advanced cardiac life support in three ambulance services (Akershus, London and Stockholm). Prototype defibrillators (Heartstart 4000SP, Philips Medical Systems, Andover, MA, USA and Laerdal Medical AS, Stavanger, Norway) registered all chest compressions via an extra chest pad with an accelerometer mounted over the lower part of sternum and ventilations from changes in transthoracic impedance between the standard defibrillator pads. The quality of CPR was analyzed off-line for 119 episodes. Numbers and differences are given as mean ± S.D. and differences as mean and 95% confidence intervals.

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[1] JKJ, LW and PAS conceived and designed the study and supervised the data collection. PAS obtained funding. JKJ analyzed the data including statistical analysis and drafted the manuscript. All authors contributed substantially to the critical revision of the paper and take responsibility for the paper as a whole.

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Results: Chest compressions were not given in cardiac arrest for 61 ± 20% of the time before intubation compared to 41 ± 18% after intubation (difference: 20% (16—24%)). Compressions and ventilations per minute increased from 47 ± 25 to 71 ± 23 (difference: 24 (19, 29)) and 5.6 ± 3.7 to 14 ± 5.0 (difference: 8.7 (7.6, 9.8)) respectively. Four cases of unrecognized oesophageal intubation (3%) were suspected from the disappearance of ventilation induced changes in thoracic impedance after intubation.
Conclusion: The quality of CPR improved after tracheal intubation, but the fraction of time without blood flow was still high and not according to international guidelines. On-line analysis of thoracic impedance might be a practicable aid to avoid unrecognized oesophageal intubation, but this area needs further research.

Introduction

Current guidelines for advanced life support (ALS)[1] state that tracheal intubation in the hands of trained and experienced rescuers is the ventilatory adjunct of choice to secure the airway and enable positive pressure ventilation during uninterrupted external chest compressions.[2] At the same time there is a warning that multiple and failed attempts may be harmful, and even short interruptions in cardiac compressions decrease the probability of successful defibrillation clinically,[3] and decrease coronary perfusion pressure, short term survival and neurological outcome in animal experiments.[4—6] Unrecognized tracheal tube displacement in a patient without spontaneous ventilation is associated with certain death and rates as high as 25% for unrecognized failed intubation by ambulance personnel have been reported.[7]

We wanted to compare the performance of CPR before and after an airway was secured by tracheal intubation. Since the guidelines are different with and without intubation, we also compared each of these two periods with the respective guidelines recommendations. Our hypothesis was that intubation reduced the time without compressions, and resulted in an increased number of compressions per minute and number of ventilations per minute, with unaltered frequency of adherence to guidelines. This was studied in a material previously used to report the overall quality of out-of-hospital ALS.[8]

We also report what appears to be a new way of detecting tracheal tube displacement, incidentally discovered by studying transthoracic impedance.

Methods

Methods and materials are presented in depth in a previous report.[8] The present description is therefore less detailed.

Study design, setting and selection of participants

In this prospective, non-randomized observational study patients older than 18 years suffering from out-of-hospital cardiac arrests were included between February 2002 and October 2003. All patients with cardiac arrest treated by six ALS ambulances in each of three ambulance services were included consecutively. The three ambulance services have different response times and organisation,[8] but orotracheal intubation of unresponsive patients is part of the standard protocol at all sites. The study protocol was approved by the regional ethics committees for Akershus (Norway), Stockholm (Sweden) and London (Great Britain) respectively. Informed consent for inclusion in the study was waived as decided by these committees in accordance with paragraph 26 in the Helsinki Declaration.[9]

Methods of measurement

Prototype defibrillators were based on a standard Heartstart 4000 (Philips Medical Systems, Andover, MA, USA) defibrillator with the addition of an extra chest pad to be mounted on the lower part of the sternum with double adhesive tape. This chest pad was fitted with an accelerometer (ADXL202e, Analog Devices, USA) and a pressure sensor (22PCCFBG6, Honeywell, USA). The heel of the rescuer's hand should be placed on top of the chest pad and its movement was considered equal to that of the sternum during chest compressions. In order to avoid registering movements of the whole patient as chest compressions, only movements of the sternal chest pad with a parallel compression force >2 kg were used in the automated analysis. Measurements of vertical movement have been validated in a manikin model.[10] Transthoracic impedance was measured by applying a near constant sinusoidal current across the standard