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Clinical paper

Point of care ultrasound for orotracheal tube placement assessment in out-of hospital setting☆

Sabina Zadel[a], Matej Strnad[a,d], Gregor Prosen[a,b,c], Dušan Mekiš[d,e,f,*]

[a] Center for Emergency Medicine, Community Health Centre Maribor, Proletarskih brigad 22, 2000 Maribor, Slovenia
[b] Department of Physiology, Faculty of Medicine, University of Maribor, Taborska 8, 2000 Maribor, Slovenia
[c] Department of Emergency Medicine, Faculty of Health Sciences, University of Maribor, Žitna 15, 2000 Maribor, Slovenia
[d] Department of Emergency Medicine, Faculty of Medicine, University of Maribor, Taborska 8, 2000 Maribor, Slovenia
[e] Department of Anaesthesiology, Intensive Care and Pain Management, University Medical Centre Maribor, Ljubljanska 5, 2000 Maribor, Slovenia
[f] Department of Anaesthesiology and Reanimation, Faculty of Medicine, University of Maribor, Taborska 8, 2000 Maribor, Slovenia

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ABSTRACT

Aim of the study: The percentage of unrecognised orotracheal tube displacement in an out-of-hospital setting has been reported to be between 4.8% and 25%. The aim of our study was to assess the sensitivity and specificity of Point-of-Care-UltraSound (POCUS) for confirming the proper tube position after an urgent orotracheal intubation in an out-of-hospital setting and the time needed for POCUS.
Methods: Our single-centred prospective study included all patients who needed out-of-hospital orotracheal intubation. After the intubation, bilateral chest auscultation and assessment of bilateral lung sliding and diaphragm excursion within POCUS were done. Spectrographic quantitative capnography was used as the reference standard to confirm a proper tube position.
Results: We enrolled 124 patients. For auscultation, sensitivity and negative predicted value were 100%, specificity was 90% and positive predicted value 30% (95% confidence interval). Sensitivity, specificity, positive predicted value, and negative predicted value for POCUS alone and for a combination of auscultation and POCUS were 100% (95% confidence interval). In three patients, we detected endobronchial tube displacement with auscultation and POCUS. Capnography failed to detect displacement in all three cases. The median time needed for POCUS was 30 s.
Conclusion: Results of our study support POCUS as an accurate and reliable method for confirming the proper orotracheal tube placement in trachea and it is feasible for out-of-hospital setting implementation. POCUS also seems to be time saving method but to make definitive conclusion more studies should be done.

1. Introduction

Maintaining of open airway and providing sufficient mechanical ventilation to a critically ill/injured patient or patient in cardiac arrest is one of the top priorities for an emergency physician. The golden standard for securing the airway is still orotracheal intubation.[1–3] The difficulty of the procedure depends on the cause that requires intubation, the anatomy of the patient, the presence of oral cavity fluid/food, the obstruction of the airway and on the experiences of the physician.

Out-of-hospital setting itself makes the orotracheal intubation more difficult even for the most experienced anaesthesiologists,[4] because of the weather conditions, noise, the lack of space, limited equipment and medication. Therefore options for the proper orotracheal tube placement are also limited. The most reliable method for confirming orotracheal tube placement in out-of-hospital setting is capnography performed with spectrographic quantitative capnography.[1,5] The specificity and sensitivity of the method is 100% but only if the capnograph waveform is interpreted by an experienced physcian.[5] Additional limitation of the method is that it cannot distinguish between endotracheal placement and endobronchial misplacement or displacement of the tube.[6]

Multiple studies have shown that Poin-of-Care-UltraSound (POCUS) is very useful for the confirmation of the proper endotracheal tube position in non-emergency and emergency situations. To our knowledge only one case has been reported regarding

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* Corresponding author at: Kotnikova ul 17, 2311 Hoče, Slovenia.
E-mail address: dusan.mekis@ukc-mb.si (D. Mekiš).

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endotracheal tube position assessment with POCUS in a prehospital setting. Other studies include cadaveric cases, patient undergoing elective operations in operating theatres or critically ill/injured patients urgently intubated in emergency departments.[6–15]

Also Zechner and Breitkreutz in their ultrasound (US)-based airway management comment conclude: "a real-time based RSI and upper airway ultrasound procedure may enhance physician confidence and decision-making in relation to tracheal tube placement and may have its place in combination with continuous capnography in emergency patients."[16] To expand the possibilities for confirming the proper orotracheal tube position in an out-of-hospital setting and maybe even to find a better method than capnography, we investigated the usage of POCUS for the endotracheal tube position conformation after an urgent orotracheal intubation in an out-of-hospital setting. Unrecognised tube misplacement or displacement can be devastating for the patient. The percentage of an unrecognised tube displacement in an out-of-hospital setting is reported to be between 4.8% and 25%.[17,18] To improve the recognition of non-proper tube placement POCUS could be useful in an out-of-hospital setting. The main goal of our study was to estimate the diagnostic accuracy of POCUS – a combination of lung sliding and diaphragm excursion assessment for confirming the proper orotracheal tube position in patients after an urgent orotracheal intubation by an emergency physician in out-of-hospital setting.

2. Methods

2.1. Study design and setting

The National Medical Ethics Committee of Slovenia approved the study. Our single-centred prospective study was conducted between January 2011 and January 2014. All patients were orotracheally intubated by emergency physician in the field that is covered by the Prehospital Unit Maribor.

2.2. Selection of participants

All orotracheal intubated patients regardless to the indication for orotracheal intubation were prospectively enrolled when investigators or study associates and portable US machine in an out-of-hospital setting were available. Trauma, non-trauma, cardiac arrest and non-cardiac arrest patients composed our study group.

Seven different emergency physicians led interventions on the field, all of them being experienced in orotracheal intubation in an out-of-hospital setting. Also all participating physicians had taken a course in Ultrasound Life Support Basic Level 1 Provider organised by the World Interactive Network Focused on Critical UltraSound (WINFOCUS) and have been performing POCUS on emergency patients for at least 2 years.

2.3. Intervention

In Slovenia there is a team of two emergency nurses and one emergency physician available for medical intervention in out-of-hospital setting. For POCUS performance we used portable SonoSite M-Turbo US machine with two available transducers: a P21x phased transducer 5–1 MHz phased array and C60x curved transducer 5–2 MHz 60 mm broadband curved array. The type of transducer was chosen by the physician, depending on circumstances. Curved transducer was used for most of the patients. Bilateral lung sliding and bilateral diaphragm excursion were observed, but transducer positions were not exactly specified.

Rapid sequence intubation (RSI) was performed for non-cardiac arrest patients. Among all the usual requirements for RSI also US machine was prepared. The medications for RSI were chosen by a physician according to the patient's pathology but all patients were paralysed with succinylcholine or rocuronium bromide. Immediately after the intubation, a detector for CO_2 was connected to the tube by a nurse who observed end-tidal CO_2($EtCO_2$) immediately, $EtCO_2$ after 6 inspirations and capnograph waveform was recorded with the Lifepack 15 mobile monitor. In the meantime the physician auscultated the patient and then POCUS-assessment of lung sliding and diaphragm excursion was performed.

Cardiac arrest patients were cardio-pulmonary resuscitated (CPR) according to the valid doctrine.[1] POCUS was performed during the 10-s compression pauses for pulse check.

If obvious displacement or misplacement of the orotracheal tube was identified in any patient at any step from the orotracheal intubation till the end of POCUS performance, the orotracheal tube was repositioned immediately. If misplacement was recognised by visualisation during direct laryngoscopy or auscultation, we re-intubated the patient immediately, even though capnography and/or POCUS had not been done. After the reposition the assessment of orotracheal tube assessment was repeated including POCUS and capnography.

The decision for re-intubation was made individually by the physician who led the intervention and was usually based on a combination of direct laryngoscopy, auscultation, capnography and POCUS results.

In case of unilateral absence of lung sliding and diaphragm excursion orotracheal tube was pulled out to a depth suited to the patient's gender and habitus and the tube position was re-evaluated.

After the intervention the physician completed the study protocol. The data on the sheet included: patient name, date of intervention, birth-date, gender, cause of intubation (trauma, non-trauma), way of intubation (rapid sequence intubation or during cardiac arrest), parameters before and after intubation (blood pressure, pulse, haemoglobin saturation (SpO_2), breathing frequency, Glascow Coma Scale) and parameters after intubation – immediate $EtCO_2$ and $EtCO_2$ after six breaths, capnography, bilateral lung sliding and bilateral diaphragm excursion, auscultation of both hemithoraces and subxiphoidly, and the number of failed intubations.

Because the teams were used for all procedures (RSI, CPR, POCUS) in the out-of-hospital setting there were no bigger difficulties to obtain the needed data.

We excluded the data of intubation attempts where the physician identified a tube misplacement before the capnographic waveform was recorded and before POCUS was performed.

2.4. Outcomes

Spectrographic quantitative capnography was considered as a reference standard. Our outcome measurements were the accuracy of auscultation for confirming endotracheal tube position compared to capnography and the accuracy of POCUS compared to capnography. We also compared the combination of auscultation and POCUS to capnography.

2.5. Analysis

For descriptive statistic we used the SPSS statistical software, version 19.0 (SPSS Inc., Chicago, IL, USA). For statistical analysis of the accuracy of methods for tube position assessment we used R to calculate sensitivity, specificity, negative predicted value (NPV) and