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Cardiopulmonary resuscitation quality during CPR practice versus during a simulated life-saving event

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Introduction. As a part of the emergency medical services, the Swedish fire brigade can increase the survival rate in out-of-hospital cardiac arrests. *Aim*. To compare the quality of cardiopulmonary resuscitation (CPR) performed by firefighters at a routine CPR practice versus when involved in a simulated life-saving event. *Methods*. In this study, 80 firefighters divided into two groups performed CPR according to guidelines: one group indoors during a routine training session; the other group outdoors during a smoke diving exercise wearing personal protective clothing and self-contained breathing apparatus. Descriptive and inferential statistics were used to analyze the data. *Results*. The results showed a tendency for the outdoor group to perform CPR with better ventilation and compression quality, as compared to the indoor group. The ventilation of the manikin was not hampered by the firefighters wearing personal protective clothes and self-contained breathing apparatus, as the Swedish firefighters remove their facial mask and ventilate the patient with their mouth using a pocket mask. *Conclusions*. Overall, the results in both groups showed a high quality of CPR which can be related to the fire brigade training and education traditions. CPR training is regularly performed, which in turn helps to maintain CPR skills.

Keywords: cardiopulmonary resuscitation; firefighter; practice; simulation; smoke diving

1. Introduction

In Sweden, firefighters are responsible for providing immediate resuscitation, including cardiopulmonary resuscitation (CPR), at all scenes of accidents. Since Sweden has a population density of 24 inhabitants/km^2 (60/mi^2) [1], in areas far from the ambulance service the fire brigade assists the inhabitants in need of prehospital emergency care [2]. All firefighters have a basic emergency medical technician (B-EMT) education and fire trucks are equipped with defibrillators and basic medical equipment. As basic life support has a positive impact on survival in patients with out-of-hospital cardiac arrest [3], integrating the fire brigade into the emergency medical services (EMS) has increased the survival rate for out-of-hospital cardiac arrests in both mixed and rural areas [4,5].

The decision to perform CPR is based on the benefits of giving the patient a chance of survival and return to a good life. This decision includes risks that the intervention will place on the rescuer [6]. However, since detailed directives for when to perform CPR are uncommon, most patients with acute, life-threatening conditions receive CPR [7].

The quality with which the CPR is given affects both the short-term and long-term survival of the patient with a cardiac arrest. Well-performed CPR comprises good quality chest compressions containing adherence to rate, depth, full recoil and fraction [8]. The chest compressions should be performed at a depth of 5–6 cm and at a rate of 100–120 compressions/min. Ventilation consists of a 1-s inflation of the patient's chest with sufficient air volume. Ventilation of the patient is conducted using basic skills with a pocket mask or bag mask, the chest compressions to ventilation ratio being 30:2 [8].

Implementing life-saving procedures like CPR in a prehospital context is more challenging than in hospitals [9]. During smoke diving, firefighters perform CPR when wearing personal protective clothing and self-contained breathing apparatus, which makes CPR more difficult [10]. The situation is further complicated by the fact that the resuscitation often has to be performed by a single firefighter.

Although EMS personnel have education and training in CPR, several studies show low quality in prehospital CPR [11,12]. Also, Cheng et al. [13] state that healthcare providers may tend to overestimate their knowledge and skills of CPR. It is therefore important to evaluate the quality of the CPR done in an acute, simulated situation compared to a normal CPR training session.

The aim of the study was to compare the quality of CPR performed by firefighters at a routine CPR practice versus when involved in a simulated life-saving event.

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2. Method

This study had a quantitative approach. Data were collected through simulation. The data collection consisted of CPR performed for 2 min by the participants during two separate events. One group performed CPR during a routine training session and one group performed CPR during a smoke diving exercise. The data were analyzed with descriptive and inferential analysis.

2.1. Participants

The participants in this study consisted of 80 firefighters divided into two groups, referred to as the indoor group ($n = 40$) and the outdoor group ($n = 40$). Age in the indoor group ranged from 23 to 64 years (M 42). The time since latest CPR training ranged from 3 to 12 months (M 9). The number of service years in the fire brigade in the indoor group ranged from 2 to 37 years (M 17). Age in the outdoor group ranged from 27 to 57 years (M 41). The time since latest CPR training ranged from 3 to 12 months (M 9). The number of service years in the fire brigade in the outdoor group ranged from 2 to 35 years (M 17). All firefighters received information about the study and were then asked to voluntarily participate. Inclusion criteria were firefighters employed for emergency response participating in scheduled practice.

2.2. Data collection

Participants in both groups performed CPR for 2 min on a Resusci Anne QCPR manikin (Laerdal, Norway) according to European Resuscitation Council (ERC) guidelines [8]. The spring simulating the thoracic resistance required 45-kg chest compressions to achieve a correct compression depth. Data were collected using a Simpad (Laerdal, Norway) connected to the manikin. The ventilation score consisted of volume and rate. The compression score consisted of depth, rate, hand placement and recoil. Achieving 100% means that all parts of the CPR are within ERC guidelines. The CPR performers did not receive any feedback about their performance during the CPR.

The indoor group performed CPR during a routine training session. The CPR simulations were conducted on the floor in a gym. Two firefighters performed either chest compressions or ventilations. The firefighters then shifted task and repeated the CPR.

The outdoor group performed CPR during a smoke diving exercise, in which the participants did not have any information regarding the content of the exercise. The manikin rescued from the building exhibited a cardiac arrest, and a single firefighter was assigned to conduct the CPR. The CPR was therefore conducted outside the burning building, in a simulated chaotic environment, with the firefighter wearing personal protective clothing and self-contained breathing apparatus.

Table 1. Ventilation and compression scores in the outdoor and indoor groups.

Item	Indoor group (%)	Outdoor group (%)	Significance
Ventilation			
M	74	78	0.675
Mdn	78	80	
Range	25–99	10–99	
Compression			
M	78	88	0.230
Mdn	87	91	
Range	22–99	26–99	

Note: Differences compared with inferential statistics using a two-tailed z test for proportions.

2.3. Data analysis

A descriptive and inferential analysis was conducted using IBM SPSS version 24. Descriptive analysis (central tendency and distribution) was used to describe the data, whereas inferential statistics (two-tailed z test) compared potential differences between the variables between groups. The level of significance used was set at $\alpha = 0.05$.

3. Ethical consideration

The study followed the ethical principals in accordance with the World Medical Association [14] about anonymity and integrity. Ethical approval was obtained from the fire-chief of the region. Informed consent was obtained from each participant.

4. Results

The aim of the study was to compare the quality of CPR performed by firefighters during two separate events, one as a routine indoor CPR practice and one as a lifesaving event during smoke diving.

There was a tendency for the outdoor group to perform CPR with better quality, better ventilation and compression quality, compared to the indoor group. The result showed a statistical difference of $p = 0.675$ between the two groups regarding ventilation, where the outdoor group had a higher percentage of correctly performed ventilation. Regarding compression, the two groups had a statistical difference of $p = 0.230$, where the outdoor group also had a higher percentage of correctly performed compressions during CPR (Table 1).

5. Discussion

The precondition for good quality CPR is that the personnel are well trained before the dispatch call [15]. Training leads to improved confidence in future emergency situations [16]. It cannot be stressed often enough that CPR must be regularly practiced, sustaining a good level of skills for the personnel. Previous studies have shown

how CPR skills deteriorate after as little as 3–6 months [15,17–19]. The use of short training sessions helps to maintain CPR skills [11,17,19,20].

The fire department is an organization with well-organized education and training habits. Being well trained in CPR involves planning before the dispatch call, which according to Monsieurs et al. [8] leads to improved resuscitation performance. One contributing reason for the high percentage of correct ventilations and compressions in this study can be because the participants were firefighters. Traditionally, firefighters work in a physically hard environment which often results in firefighters having good physical condition. Research shows that the rescuer's body weight, body height, physical fitness and muscle strength are positively associated with CPR quality [21–23]. Body size and muscle strength provide deeper compressions that have a positive impact on patient survival [24,25].

Firefighters perform CPR wearing personal protective clothing and self-contained breathing apparatus. Studies show that there is a risk that patient ventilation will be hampered when wearing personal protective clothes [10]. This does not correlate with our study, where patient ventilation had a mean of 78% in the group wearing protective clothing and self-contained breathing apparatuses. This result is probably due to the participants taking off the face mask of their breathing apparatus to ventilate the patient with a pocket mask. The fire brigade in Sweden always ventilates the patient using a pocket mask with additional oxygen flow. In the military context, pocket masks have proved to require repeated training to master, but with training resulted in a ventilation of 97% [20]. Jeong et al. [26] argue that basic airway management, such as pocket masks, leads to lower survival chances for patients, as compared to advanced airway management. On the other hand, Ohashi-Fukuda et al. [27] show that there is no difference in neurologically favorable survival between advanced airway management and basic airway management.

6. Conclusion

There was a tendency for the outdoor group to perform CPR with a slightly better ventilation and compression quality, as compared to the indoor group. Overall, the results in both groups showed a high quality of CPR which can be related to the fire brigade's training and education traditions. CPR training is regularly performed, which in turn helps to maintain the CPR skills. The Swedish firefighters remove their facial mask and ventilate the patient with their mouth using a pocket mask with additional oxygen flow, which does not hamper the patient ventilation quality.

7. Limitations

One limitation is that there were two different groups performing the indoor CPR and the outdoor CPR. Another limitation is that a manikin-based study cannot mimic real-life resuscitation situations. A manikin has no variations, as real people have. In this study, participants had full focus on CPR, and not what was happening in the surrounding environment as they should have during a real cardiac arrest.

The defibrillation of the patient was not part of this study. Early defibrillation within 3–5 min of the cardiac arrest improves the probability of survival [6,9]. This may also be a limitation, as it was not included in the resuscitation.

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