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Clinical paper

Implementation and use of a supraglottic airway device in the management of out-of-hospital cardiac arrest by firefighter first responders – A prospective feasibility study

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Abstract

Aim: We wanted to assess the implementation and use of a supraglottic airway (SGA) for on-call firefighter first responders in out-of-hospital cardiac arrest.

Methods: We trained 502 firefighter first responders, located at 35 fire stations in the South-East of Norway, in the use of SGA during cardiopulmonary resuscitation in adult out-of-hospital cardiac arrest. Training consisted of 45 minutes of theoretical and practical training in small groups. Primary outcome was successful ventilation with SGA assessed by both firefighter first responders and first paramedic arriving on-scene. Secondary outcomes included time expenditure and complications related to the procedure, evaluation of the training, and descriptive characteristics of the out-of-hospital cardiac arrest cases.

Results: An SGA was used by firefighter first responders in 23 out-of-hospital cardiac arrests, and successful ventilation was achieved in 20 (87%) cases. Air-leak was described in the three unsuccessful cases. The median procedural time was 30 seconds (IQR = 15–40), with no observed procedural complications. Firefighter first responders arrived in median time 9 minutes (IQR = 6–10 min) before the ambulance. They performed chest compressions on all patients and 6 (26%) of the patients received shock with semi-automatic external defibrillator. After training, all participants were able to successfully ventilate a manikin with the SGA. The cost of the SGA equipment for all fire stations was 3955 GBP.

Conclusion: Implementation of an SGA for firefighter first responders in out-of-hospital cardiac arrest management seems feasible, safe and can be introduced with limited amount of training and limited use of resources.

Keywords: Firefighter, First responder, First responder training, Out-of-hospital cardiac arrest, System saving lives

Introduction

Patients with out-of-hospital cardiac arrest (OHCA) requires an effective chain of survival to optimize outcome.[1] Key components are early cardiopulmonary resuscitation (CPR) and defibrillation, hence the importance of telephone guided CPR instructions to the caller, as well as alerting first responders to start treatment before ambulance arrival.[2–4]

Several different first responder systems have been described,[5–8] and firefighters often represent an important part of medical preparedness in rural regions.[9–12] In Norway, fire departments remain more decentralized than the ambulance services, and on-call firefighter first responders are increasingly utilized as first responders in medical emergencies.

Open airways and ensuring oxygenation are of paramount importance in all aspects of emergency medicine.[13] The recommended prehospital airway management strategy depends on operator com-

Abbreviations: SGA, Supraglottic airway, OHCA, Out-of-hospital cardiac arrest, CPR, Cardiopulmonary resuscitation, EMS, Emergency Medical System, ETI, Endotracheal intubation, ROSC, Return of spontaneous circulation.

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petency.[14] Firefighter first responders in Norway currently use mouth-to-mask ventilation in OHCA.

Previous reports from implementing supraglottic airway (SGA) devices in OHCA resuscitation by firefighter first responders have been promising, with 88% and 94% SGA success in similar studies.[15,16] However, resuscitation guidelines are not specific in terms of recommended airway management options for non-medical personnel and the optimal airway management strategy during resuscitation by first responders remains unknown.[17]

The aim of this study was therefore to assess the feasibility of implementing a second-generation SGA for firefighter first responders in adult OHCA. We hypothesized that firefighter first responders would achieve ventilation with an acceptable success rate with limited amount of training and resource use.

Methods

Design

The study is a prospective interventional feasibility study with consecutive recruitment of on-call firefighter first responders from Norwegian fire departments to implement the use of an SGA in adult OHCA.

Setting and participants

The paramedic-manned ground ambulance is the cornerstone in the Norwegian Emergency Medical System (EMS). Ambulances are centralised to a larger degree than the fire department because, by regulation, the fire department must be able to reach defined risk objects within 10 minutes,[18] while for the EMS services it is stated that an ambulance should reach 90% of emergency patients within 12 minutes in cities, and within 25 minutes in rural areas.[19]

The Norwegian health authorities have endorsed the organised and systematic use of firefighter first responders to improve the chain of survival for OHCA and other suspected life-threatening conditions.[20] Emergency Medical Dispatch Centre relay calls where need for firefighter first responders is identified to the Fire Dispatch Centre, who in turn alarms the nearest fire department. Firefighter first responders respond to both medical and traumatic incidents. Fire departments are barracked in the cities and organised with part time firefighters responding from their home or primary workplace in more rural areas. This makes on-call firefighter first responders a readily available and important addition in medical preparedness in Norway.

Firefighters in Norway have regular training in basic first aid and CPR. In addition, all participating fire departments had previously been trained by The Norwegian Air Ambulance Foundation in the project “While waiting for the ambulance”. This training consists of pre-course electronic teaching resources and 8 hours of on-site theoretical and practical instructions in emergency medicine topics, including an annual recertification. Standard medical equipment for firefighter first responders during CPR includes semi-automatic external defibrillators, oxygen, and mouth-to-mask as the default method for ventilation.

Thirty-eight fire stations (5 full-time, 30 part-time) in the South-East of Norway were invited to participate in the study, including the fire stations at Oslo Airport Gardermoen with approximately 26,000 travellers each day in 2021. A formal invitation to participate in the study was directed to the fire chief at each station. The included fire departments were consecutively recruited during a period from December 2020 to October 2022. The data collection was continued until 31st of January 2023.

Training and implementation

Participating firefighter first responders received a structured and standardized 45-minute training program at their fire department. All firefighters completed the training in their work time. A theoretical lecture was followed by a practical training session where participants were trained to use the iGel® (Intersurgical, Wokingham, England) SGA during CPR in adult OHCA. The iGel® is a second-generation SGA widely used in resuscitation by ambulance personnel.[21] The lecture was developed by the study group for the purpose of this study.

After training all participants demonstrated adherence to the protocol with practical use on an airway manikin (Crash Kelly, Laerdal Medical, Stavanger, Norway) (Fig. 1).

At study start the participating fire stations received one emergency airway pack with the following equipment: iGel® in adult sizes (Number 3, 4 and 5), disposable self-expanding bag resuscitator and a high-visibility instruction card. Used airway packs were replaced from the ambulance service or immediately delivered from the study group. The cost was estimated to approximately 113 GBP per station.

Data collection and outcome measures

Predefined questionnaires for firefighter first responders and ambulance personnel were used for data collection in adult OHCA cases (Supplement). If SGA use was unsuccessful, supplementary details were obtained from involved personnel. Data from training sessions were collected by the study group.

The primary outcome measure was successful SGA ventilation defined as adequate chest-rise determined by visual inspection and / or confirmation of chest expansion with hand placed on

Fig. 1 – On-call firefighter first responder performing SGA procedure on manikin.

patient's chest wall. This was assessed independently by firefighter first responders and by the first paramedic arriving on-scene.

Secondary outcomes included time expenditure and complications related to the SGA procedure, other tasks performed by firefighter first responders in OHCA cases, performance measures related to SGA use after training, and return of spontaneous circulation (ROSC).

Time expenditure was defined as the interval from firefighter first responders opening of the SGA-package to the first successful ventilation with self-expanding bag resuscitator. Complications was defined as damage to teeth, damage to upper airway soft tissue, or bleeding or aspiration that occurred during the procedure. Administration of oxygen, performance of chest compressions, connection and use of semi-automatic external defibrillators and other tasks such as assisting patient evacuation and safe landing of ambulance helicopter were registered in a check-off form.

Performance measures after training was evaluated by the study group who registered adherence to pre-defined procedural steps on the airway manikin at the end of the training session (Fig. 1). The following procedural steps were observed: opening and lubricating the SGA, establishing sniffing-position, lifting jaw and correct placement of SGA, appropriate use of self-expanding bag resuscitator, and finally appropriate verification of chest-rise.

Data regarding travelers at Oslo Airport Gardermoen were collected from Statistics Norway.[22]

Statistical methods

Performance indicators are presented as numbers and percentages. Procedural time measurements and time intervals from firefighter first responders to EMS arrival are presented with median values and interquartile ranges (IQR). Results are listed in the tables in absolute numbers (n) and percentages of the total (%).

Ethics

Data handling was approved by, and in accordance with, the local Data Protection Officer at Vestre Viken Health Trust (Ref. no.: 20/09216-1) and Innlandet Health Trust (Ref. no.: 19735147). The Regional Ethics Committee exempted the study from formal ethical approval (Ref. no.: 159270). Participation was voluntary and individual firefighter first responders at participating fire stations had the option not to participate. All firefighter first responders signed an informed consent form. All surviving patients received written information about the study which included the option to withdraw their data from the study.

Results

All eligible on-call firefighter first responders ($n = 502$) in the included fire departments participated in the study. The participants represented 35 of the 38 invited fire departments covering an area with approximately 315,000 inhabitants in South-East of Norway, including the fire stations at Oslo Airport Gardermoen.

Results from adult OHCA cases

Firefighter first responders used the SGA in 23 adult OHCA. The SGA use led to successful ventilation in 20 (87%) of the cases (Table 1). In 18 (78%) of the 23 cases the SGAs were successfully placed on the first attempt. The median time for successful procedures, measured from opening of the SGA-package to first successful ventilation, was 30 seconds (IQR = 15–40). The firefighter first responders and paramedics assessment of chest-rise and successful ventilation was identical in all cases.

Air-leak was described in all three cases where the SGA was unsuccessful. In two cases Air Ambulance physicians attended the scene and tried the SGA without success before proceeding with endotracheal intubation (ETI). In both cases the physicians reported obesity as a probable cause for difficult SGA-ventilation. In the third case of unsuccessful ventilation there was massive aspiration observed before the SGA-procedure. The arriving paramedic did not achieve ventilation with the SGA in this patient.

The median time for firefighter first responders arrival before ambulance service was 9 minutes (IQR = 6–10). In this period, they contributed to a range of therapeutic and logistical measures (Table 1). Firefighter first responders performed chest compressions on all patients and connected a semi-automatic external defibrillator to 22 (96%) of the patients. Shock was delivered to the six patients that presented with shockable initial rhythm, and all of these obtained initial ROSC.

Sixteen (70%) of the OHCAs were believed to be of primary cardiac origin. Three (13%) other medical emergencies and 3 (13%) with unknown etiology. One (4%) incident was trauma. Sixteen (70%) of the responses were in private homes, and 7 (30%) were in public places.

Oxygen was administered in 18 (78%) of the cases. After arrival of the ambulance, firefighter first responders assisted the EMS with various tasks, e.g. carrying patient on stretcher and assistance in Air Ambulance landing (Table 1).

Results from manikin training

After training all participants were able to place the SGA in a manikin with a maximum of two attempts and demonstrated good technical skills in the procedural steps emphasized during training (Table 2).

The SGA equipment distributed to the 35 fire departments sums up to a total cost of approximately 3,955 GBP.

Discussion

In our study we found that firefighter first responders were able to successfully place an SGA and ventilate 20/23 (87%) adult patients in OHCA. The 502 participants were trained and equipped using a limited amount of resources and demonstrated good technical skills after training.

Implementation of SGAs have previously been described with high success rate in different first responder systems. In Germany first responders from the Red Cross used same SGA in 59 OHCAs and found the SGA use easy or only slightly difficult in 88% of the cases.[15] Similar results were found in a study of firefighter first responders in Finland where the use of a double cuffed laryngeal tube (Kings LTS®), resulted in visible chest movement in 59/63 (94%) of patients, with median procedural time 23 seconds.[16]

A Norwegian study of paramedic use of SGA in adult OHCA found higher success rates for placement of iGel® compared with Kings LTS®, 86% versus 75%, respectively.[23] A large retrospective study with 9456 cases made the same comparison, and also found the iGel® to be favorable with 95% first-pass successful placement, compared to 90% for Kings LTS®.[24]

These studies indicates that the overall success rate in our study corresponds with results from both first responder and paramedic

Table 1 – Description of on-call firefighter first responders' clinical interventions in 23 OHCA responses in absolute numbers (n) and percentages (%).

	Performed by firefighter first responder
SGA procedure (Primary outcome):	
SGA attempted by firefighter first responders	23 (100)
Successful SGA-ventilation (*) assessed by firefighter first responders	20 (87)
Successful SGA-ventilation (*) assessed by paramedic	20 (87)
SGA procedure (Secondary outcome):	
Air leak after SGA insertion assessed by firefighter first responders	3 (13)
Complications related to SGA procedure (**)	0 (0)
Other tasks performed by firefighter first responders during CPR (Secondary outcome):	
Oxygen administration	18 (78)
Chest compressions	23 (100)
Semi-automatic external defibrillator, connected	22 (96)
Semi-automatic external defibrillator, shock delivered	6 (26)
Carrying patient on stretcher, assistance	8 (35)
Assistance to Air Ambulance landing	10 (44)

(*) = Adequate chest-rise during ventilation.
(**) = Damage to teeth, damage to upper airway soft tissue, or bleeding or aspiration that occur during the procedure.

Table 2 – 502 on-call firefighter first responders airway management performance with SGA on a manikin after training in absolute numbers (n) and percentages (%).

Procedural steps	Performed by firefighter first responder
Correct unpacking and preparing of equipment	485 (97)
Checking sniffing-position	481 (96)
Lifting jaw to facilitate insertion	459 (91)
Correct first pass placement of SGA	495 (97)
Correct second pass placement of SGA (*)	13 (3)
Appropriate use of self-expanding bag resuscitator and verification of chest-rise	497 (98)

(*) = If first pass placement was unsuccessful.

use of SGA in OHCA. There were no complications directly related to the SGA procedure during the study, and the time expenditure is interpreted as reasonable.

In three (14%) of the cases firefighter first responders were not able to ventilate the patient with an SGA and further data were collected from involved personnel. In these cases, neither the arriving paramedic nor the Air Ambulance physicians were able to ventilate with an SGA. This suggests that it was not the level of firefighter first responder's airway management skills that caused failure to ventilate, but rather that it was patient factors such as obesity and aspiration that made SGA ventilation difficult.

The default airway strategy for Norwegian firefighter first responders is mouth-to-mask ventilation, which is associated with a distinctively lower success rate than SGA devices.[25] A study of different manual air-inflation strategies showed tendencies to variations in tidal volume and more air entry into the stomach, and can be an argument in favor of exploring other airway strategies.[26]

The SGA directs air stream towards the laryngeal opening and design features are intended to provide a more secure airway with partial protection against aspiration compared with mouth-to-mask ventilation. An SGA represents an intermediate level of airway management between conventional mouth-to-mask and ETI. The use of SGAs in OHCA is widespread in paramedic-based EMS, while ETI is only reserved for specially trained resources.[24] Hesitation to perform mouth-to-mouth ventilation in OHCA is also described among health care workers and can in our opinion be a contributing argument for the use of SGA in an on-call firefighter first responders system.[27]

Firefighter first responders´ primary responsibility is firefighting and rescue-services. Ideally, additional duties should not be associated with high costs or time-consuming training. The total cost of SGA equipment in the 35 participating fire departments were moderate, and the training program was time-efficient and carried out at the firefighter first responders' own location. The evaluation of firefighter first responders SGA-procedure after the lecture showed good technical performance and when interpreted in combination with the results from the OHCA cases, we believe that the training was appropriate and sufficient.

Initiation of high-quality chest compressions and early defibrillation are of clinical importance for survival in OHCA.[17] Studies of firefighters responding to OHCA in similar systems have shown improved 30-day survival.[28]

In 2022 in Norway urgent emergency medicine assignments constituted more than 5% of the fire departments annual tasks. This sums up to almost 25,000 missions per year, most of these are not associated with cardiac arrest.[29] In rural areas firefighter first responders must treat the patient for a considerable period before

they are relieved by the EMS. [28,30] In our study firefighter first responders arrived on average 9 minutes before the EMS. During this time a semi-automatic external defibrillator was connected to nearly all patients, and all patients with shockable initial rhythm were defibrillated. And, in line with a previous study, firefighter first responders contributed in various tasks also after arrival of the EMS.[31]

The relatively low number of included cases with OHCA implies that the results regarding success- and complication rates must be interpreted with caution. ROSC is reported, but we cannot relate this to the SGA procedure. Data on firefighter first responders' performance were partly self-evaluations, although their findings were supported by evaluation by EMS personnel upon their arrival. Due to requirements for anonymity the study does not present patient characteristics. The study implemented an SGA device that replaced the use of mouth-to-mask ventilation. To further compare these ventilation strategies, a control group using mouth-to-mask would have been valuable. Among several factors, the Covid-19 pandemic, made a case-control study design difficult. Several firefighter first responders reported reluctance to use the mouth-to-mask during the pandemic due to fear of contamination. For the same reason the Covid-19 pandemic may have facilitated the implementation of the SGA and positively affected the willingness to participate in the study.

Conclusion

On-call firefighter first responders are a readily available resource that is already a major contributor in OHCA. Firefighter first responders must be prepared to deliver care on their own for a relatively long period. This must be reflected in their training and equipment.[17] Optimal ventilation-strategies for firefighter first responders must be defined. In this study, the use of SGA in adult OHCA resulted in acceptable rates of successful ventilation within a reasonable time expenditure, and with no reported complications. The implementation was associated with limited resource use, and high willingness to participate among firefighter first responders. The results support the implementation and use of the iGel® SGA by firefighter first responders in OHCA.

Further studies regarding on-call firefighter first responders and their importance in the management of OHCA are welcomed.

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CRediT authorship contribution statement

Åke Erling L. Andresen: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Magnus Varild Lauritzen:** Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Jo Kramer-Johansen:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Thomas Kristiansen:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2023.100480.

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