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An observational study on survival rates of patients with out-of-hospital cardiac arrest in the Netherlands after improving the 'chain of survival'

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ABSTRACT

Objectives To evaluate the impact of implemented procedures for out-of-hospital cardiac arrests (OHCAs) by determining patient outcome defined as the percentage return of spontaneous circulation at arrival at the emergency department, and 3-month and 1-year-survival rates.

Design Observational study.

Setting Primary emergency medical care consisting of Advanced Life Support is given by ambulance nurses and secondary care by hospitals within the mid-western part of the Netherlands covering 750 000 inhabitants.

Participants 433 of 500 consecutive patients with OHCA were included in the study over a 1.5-year period.

Outcome measures Analysis included number of patients with return of spontaneous circulation (ROSC) when handed over to the emergency department, survival at 3 months and 1 year including a comparison with global outcome rates. We further considered the influence of gender, delays, bystander Basic Life Support, use of an automated external defibrillator, initial rhythm and mechanical thorax compression in combination with Boussignac tube ventilation.

Results 13% (67/500) of the initial patient population was excluded from the analysis as reanimation in these patients was aborted due to expressed wish not to be resuscitated. Resuscitation was started by bystanders, police and/or first responders in 312/433 (72%) cases. An automated external defibrillator was used in 198 of these 312 cases (63%) of which it defibrillated 108 times. Mechanical thorax compression in combination with Boussignac tube ventilation was necessary in 277/433 patients (64%). Spontaneous circulation returned in 96/277 (35%) patients of this group. In the overall studied population, ROSC percentage at arrival at the hospital was 214/433 (49%). The 3-month and 12-month-survival rates were 123/433 (28%) and 119/433 (27%), respectively.

Conclusions Optimised 'chain of survival' for patients with OHCA resulted in ROSC in 49% of the cases and a 1-year-survival rate of 27% in the studied population.

Strengths and limitations of this study

- This is a prospective, observational study in a relatively large population (n=500).
- The results of the study were obtained after standardised evaluation of resuscitations.
- This study did not utilise a blind or randomised design.
- The outcome measures did not include neurological outcomes.
- Comparisons were made to global data and not to matching controls.

BACKGROUND

Improving the outcome of out-of-hospital cardiac arrest (OHCA) is still a major healthcare challenge, particularly for ambulance services responsible to treat patients according to the pertaining cardiopulmonary resuscitation (CPR) guidelines/protocols.[1]

Introducing new aids or combining existing aids improves the quality of resuscitation. However, an integrated approach by optimising the 'chain of survival' is considered to have more impact on the outcome of patients with OHCA.[2] Therefore, the Dutch Regional Ambulance Service Hollands Midden (RAVHM) implemented a combined series of interventions with the intent to provide comprehensive care to patients with OHCA and improve their survival.

The RAVHM region covers 875 km^2 and consists mainly of urbanised countryside in the mid-western region of the Netherlands. RAVHM provides ambulance services from 9 locations and 31 vehicles, serving approximately 775 000 inhabitants. RAVHM receives about 65 000 ambulance calls annually, of which 42% have high priority.

During the period from 2006 to 2010, RAVHM has invested in a series of initiatives to improve the chain of survival. The dispatch centre developed standardised instructions that are used to assist callers and/or bystanders to provide optimal Basic Life Support (BLS).

Police and fire departments were equipped with automated external defibrillators (AEDs), and officers were specifically trained by ambulance staff to perform optimal BLS. Finally, the ambulance staff of RAVHM was certified to perform resuscitation with the Lund University Cardiopulmonary Assist System (LUCAS; Jolife AB, Lund, Sweden) and the Boussignac tube was introduced.[3 4] This endotracheal tube allows continuous insufflation of oxygen at a flow of approximately 15 L/min resulting in a continuous positive airway pressure of 5–8 cm H_2O. Thereby, the lungs are continuously supplied by oxygen while CO_2 can escape through the open end of the tube.[5] In combination with the LUCAS, air and oxygen insufflation is initiated and maintained by exchange of active compression and decompression of the thorax.[6] The combined use of LUCAS and Boussignac tube ensures a constant oxygenation and ventilation, independent of the skills of the ambulance personnel.[7] The impact of these measures has previously been evaluated in the context of out-of-hospital resuscitation; the effect of public education,[8] adequate oxygen supply[9] and the use of mechanical chest compression devices.[10] However, to the best of our knowledge, this is the first systematic evaluation of the impact of a comprehensive set of measures aimed to improve patient outcome. Results are presented using the standardised UTSTEIN template for uniform reporting of cardiac arrests.[11]

Therefore, the aim of this study was to systematically evaluate the impact of this optimised 'chain of survival' approach on the outcome of patients with OHCA. In addition to survival rates, we investigated the influence of different conditions/variables on patient outcome.

The full study protocol is available in the online supplementary file 'Protocol RHM study'.

METHODS

Study design and participants

This observational, prospective study was conducted in the western part of the Netherlands, from November 2011 until 4 April 2013. The Medical Ethics Committee of Leiden University Medical Centre approved the study protocol. The study is registered in a public trial registry (ISRCTN 42987115).

The study was coordinated by RAVHM and data were collected in a uniform way using template data collection forms and read-outs from equipment. Outcome data were obtained from the hospitals using a standard questionnaire, considering privacy laws. All data were subsequently stored in a central database located at the site of the ambulance service.

This study included 500 consecutive patients with cardiac arrest for whom assistance of RAVHM was called. All suspected cardiac arrest cases that were brought to the attention of the ambulance service in the time period of the study were included in chronological order. No selection occurred at the time of call.

Time of call to the dispatch centre, ambulance and monitor times were extracted from a validated time keeping system (OpenCare Ambu V.1.10/1.11; Centric, Gouda, The Netherlands).

On arrival, ambulance staff administered CPR and monitored heart rhythm as quickly as possible. Optional defibrillation, manual thorax compressions and ventilation using bag valve mask (FiO_2 1.0) with ratio 30:2 were applied. Subsequently, mechanical compressions were performed by a LUCAS device. Immediately after LUCAS was in operation, patients were intubated with the Boussignac tube. Defibrillation was prioritised over intubation. All ambulance staff members were certified to apply and use the LUCAS and Boussignac tube. Utilisation of these devices was according to standard operating procedures of RAVHM.

All data were obtained from the Ambulance Ride Form (ARF), the case report form (CRF) and Lifenet Code-Stat Reviewer 8.0 (Physio-Control). Patient data including diagnosis, treatment, the course of the OHCA and vital signs were registered on the ARF. Additional study-specific data were documented using a CRF based on the most recent version of the UTSTEIN template for Resuscitation Registries.[11] These included end-tidal CO_2 ($etCO_2$), peripheral oxygen saturation (SpO_2), use of devices (LUCAS, Boussignac tube, other), awareness status during mechanical thorax compression and complications due to resuscitation. Missing data from ARF or CRF were extracted from Lifenet Code-Stat Reviewer 8.0.

The primary outcome was the number (percentage) of patients with return of spontaneous circulation (ROSC) at arrival at the hospital emergency department (ED), and 3-month and 1-year-survival rates. Secondary outcomes were ROSC percentages differentiated for gender, initial rhythm, bystander BLS (yes/no), AED use (yes/no), use of LUCAS and Boussignac tube and delay start BLS.

Data are provided as means (±SD) or median (range) when appropriate. Statistical analyses included Pearson's χ^2 tests for dichotomous or categorical variables and were done using IBM SPSS Statistics for Windows, V.20.0. Armonk, NY.

Patient and public involvement

Direct patient involvement in the prehospital emergency medicine field is rare and uncommon. However, indirect involvement of patients was obtained by submitting the protocol to the Medical Ethics Committee, which has patient's representation. This study shows the results of optimising the chain of survival without any additional experimental intervention, hence no burden for the patients was incurred, as all patients were treated according to the resuscitation guidelines. The results of this study will be further disseminated by presenting the publication to the Resuscitation Committee (*Reanimatieraad*) and other Ambulance Services in the Netherlands. The study results will be presented at local and (inter) national relevant conferences.

RESULTS

Patient characteristics and outcomes

A tabular overview of the study results is provided in table 1. From the total of 500 consecutively included patients in whom resuscitation was attempted, 67 (13.4%) patients were excluded based on Do Not Attempt Resuscitation instruction or medical futility. The average age of all included patients was 65 (range: 0–100) years. Most patients 306/433 (71%) were men.

The analysed OHCA events occurred in or around home (67%), in a public place (29%) or in the ambulance (4%). Most OHCA had a cardiac cause (79%).

CPR was unsuccessful in 94 (22%) of the 433 evaluable patients and were pronounced dead at the site of occurrence and not transported to the hospital. The remaining 339 patients (78%) were transported to the ED for further treatment. At handover to the ED staff, 214 patients (49%) had ROSC. The overall 3-month-survival rate was 28% (123 patients) and 119 patients (27%) survived for at least 1 year.

Dispatch, bystander and first responder CPR

In 55% (240 of 433) of the cases, the arrest was 'witnessed'. The average time between reporting an OHCA to the dispatch centre and the arrival of the ambulance at the scene was 9 (SD ±3) min. During the time between the call to the emergency centre and the arrival of the ambulance, bystanders were given appropriate instructions from the dispatch centre and started guided BLS in 72% (312 of 433). In 80 of these 312 (26%) patients, BLS was started within 1 min. Resuscitation was started by first responders of the fire department in 35 patients. Police staff resuscitated 160 times before the ambulance arrived either as first responder or overtaking bystander CPR. The AED was used in 198 of 433 (63%) cases, as part of the BLS. In 108 cases, the AED defibrillated, resulting in ROSC in 23 cases (12% of the AED-connected patients).

Not starting BLS prior to ambulance arrival resulted in the lowest percentage (42%) of patients with ROSC on arrival at the hospital. Bystander started BLS (49%), resuscitation by first responders (46%), general practitioner/medical staff (44%), family/friends (43%) and police (44%) all resulted in higher ROSC outcomes.

In 50% (216 of 433) of the cases, an initial shockable rhythm was observed. BLS with or without AED use resulted in 48% (96 of 198) and 51% (58 of 114) ROSC at ED, respectively. Of the 47 witnessed monitored arrest (WMA) cases registered, a shockable rhythm was observed in 23 patients. In this group, ROSC was achieved 21 times (91%). This contrast sharply with only 33% (8 of 24) ROSC if no shockable rhythm was present.

Devices: effects and complications

Mechanical compression using the LUCAS was used 328 times by the ambulance staff after resuscitation was started with manual thorax compressions (table 2). When LUCAS was applied, blood pressure measurement was not always performed but was measurable in at least 153 cases. During device-assisted resuscitation with LUCAS, motoric symptoms were observed, without heart rhythm compatible with life, in 53 (16%) patients. The observed motoric symptoms included grimace, restlessness, trismus and/or open eyes.

No device-related complications/side effects were detected by the ambulance personnel in 56% of patients resuscitated with the LUCAS. In 44% of the patients, side effects included skin abrasion caused by the suction cup of the LUCAS (in 26% of patients), suspicion of rib/sternum fracture (in 14% of the patients), lung secretions in the Boussignac tube (5% of the patients) and in 4% other complications were reported (table 2). Careful further diagnostic and/or radiological assessments in the hospital did not reveal lung haemorrhages nor other complications.

Supported ventilation was necessary in almost all patients. In approximately 15% of the patients, intubation failed and the laryngeal mask airway-Supreme was used. Intubation was performed with a standard endotracheal tube in 32 patients (7% of the total population), and the Boussignac tube in 290 (67%) of the 433 patients. Simultaneous use of the Boussignac tube and the LUCAS device occurred in 277 (64%) patients and in 13 cases the tube was used without LUCAS. All cases allowed side stream registered continuous $etCO_2$ measurements proximal to the tube. This provided continuous graphics and metric values during compressions with the LUCAS. SpO_2 was measurable in 202 cases using a pulse oximeter. Combined use of LUCAS and Boussignac tube resulted in ROSC at ED for 96/277 (35%) patients.

Witnessed/non-witnessed

The majority of the cardiac arrests (n=287, 66%) were witnessed arrests (table 3). In this group, the ROSC percentage was higher compared with the group of patients with non-witnessed arrests (56% vs 37%, p=0.0002, χ^2 test). The highest percentage of ROSC was achieved with WMAs with a shockable rhythm (91%) while in patients in whom the arrest was witnessed but proved to be non-shockable rhythm only 33% achieved ROSC on the ED (p=0.0001, χ^2test). No significant differences in outcome were found between men and women (48% vs 53%).

First monitored rhythm

Patients presenting with shockable rhythms as the first monitored rhythm had a twofold higher ROSC (67%) compared with patients with non-shockable rhythms (32%). The difference was highly statistically significant p<0.0001 (χ^2test). In 108 of all patients with a shockable rhythm (n=216), an AED was connected. In 64 of the 108 cases (59%) this resulted in ROSC on ED. ROSC percentage of 74% was achieved without using an AED (80 of the 108 patients; p=0.02, χ^2 test).

Women with an initially shockable rhythm got ROSC in 78% (42 of the 54 times), while this 63% (102 of the 162 patients) in men (p=0.046, χ^2 test). No gender

Table 1 Patient characteristics presented as per UTSTEIN template

Data name	Total no. (%)	Male no. (%)	Female no. (%)
Absence of signs of circulation and/or considered for resuscitation	**500 (100%)**	345 of 500 (69%)	155 of 500 (31%)
Resuscitation not attempted	**67 of 500 (13%)**	39 of 345 *(11%)*	28 of 155 *(18%)*
Do Not Attempt Resuscitation order present	6 (1%)	4	2
Attempt considered futile	61 (12%)	35	26
Signs of circulation present	Excluded		
Resuscitations attempted	**433 of 500 (87%)**	306 of 345 (89%)	127 of 155 (82%)
Any defibrillation attempt	216 (50%)	162 *(53%)*	54 *(43%)*
Chest compressions (and/or Lund University Cardiopulmonary Assist System)	328 (76%)	229 *(75%)*	99 *(78%)*
Aetiology (multiple entry possible)			
Presumed cardiac	343 of 433 (79%)	242	101
Trauma	15 of 433 (3%)	11	4
Submersion	6 of 433 (1%)	5	1
Respiratory	22 of 433 (5%)	17	5
Other non-cardiac	39 of 433 (9%)	27	12
Unknown	96 of 433 (22%)	64	32
Arrest witnessed/monitored	**287 of 433 (66%)**	200 of 306 *(65%)*	87 of 127 *(69%)*
Laypersons	240 (84%)	166	74
Healthcare providers	47 (16%)	34	13
Arrest not witnessed	**146 of 433 (34%)**	106 of 306 *(35%)*	40 of 127 *(31%)*
First monitored rhythm shockable	**216 of 433 (50%)**	162 of 306 *(53%)*	54 of 127 *(43%)*
Ventricular Fibrillation	198 (46%)	150 *(49%)*	48 *(38%)*
Ventricular Tachycardia	13 (3%)	8 *(3%)*	5 *(4%)*
Unknown AED shockable rhythm	5 (1%)	4 *(1%)*	1 *(1%)*
First monitored rhythm non-shockable	**217 of 433 (50%)**	144 of 306 *(47%)*	73 of 127 (57%)
Asystole	112 (26%)	79 *(26%)*	33 *(26%)*
Pulseless Electrical Activity	78 (18%)	48 *(16%)*	30 *(24%)*
Bradycardia	26 (6%)	16 *(5%)*	10 *(8%)*
Other	1 (0%)	1 *(0%)*	0 *(0%)*
Unknown AED non-shockable rhythm	0 (0%)	0 *(0%)*	0 *(0%)*
CPR before Emergency Medical Services (EMS)	**312 of 433 (72%)**	225 *(74%)*	87 *(69%)*
Use of AED before EMS	**198 of 433 (46%)**	150 of 306 *(49%)*	48 of 127 *(38%)*
Percentage AED use of CPR before EMS	198 of 312 *(63%)*	150 of 225 *(67%)*	48 of 87 *(55%)*
Defibrillation by AED	108 of 198 *(55%)*	88 *(59%)*	20 *(42%)*
ROSC after AED	23 of 198 *(12%)*	21 *(14%)*	2 *(4%)*
Any ROSC			
Yes	**255 of 433 (59%)**	176 of 306 *(58%)*	79 of 127 *(62%)*
No	**178 of 433 (41%)**	130 of 306 *(42%)*	48 of 127 *(38%)*
Survived event to emergency department/intensive care unit	**214 of 433 (49%)**	147 of 306 *(48%)*	67 of 127 *(53%)*
Discharged alive (nine missing)	**129 of 433 (30%)**	Unknown	Unknown
Alive after 3 months (nine missing)	**123 of 433 (28%)**	Unknown	Unknown
Alive after 1 year (nine missing)	**119 of 433 (27%)**	Unknown	Unknown
Location of arrest: out-of-hospital			
Home/residence	**292 of 433 (67%)**	187 of 306 *(61%)*	105 of 127 *(83%)*

Continued

Table 1 Continued

Data name	Total no. (%)	Male no. (%)	Female no. (%)
Industrial/workspace	**10 of 433 (2%)**	8 of 306 *(3%)*	2 of 127 *(2%)*
Sport/recreation event	**14 of 433 (3%)**	14 of 306 *(5%)*	0 of 127 *(0%)*
Street/public building	**98 of 433 (23%)**	84 of 306 *(27%)*	14 of 127 *(11%)*
Other, in ambulance	**19 of 433 (4%)**	13 of 306 *(4%)*	6 of 127 *(5%)*

Italic items are in comparison to subgroup totals.
Bold items are percentages and number of the total group, otherwise they are figures of subgroups.
AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation.

differences in ROSC outcome were observed in patients with an initially non-shockable rhythm.

DISCUSSION

It seems theoretically plausible that investing in the optimisation of the out-of-hospital measures for optimal CPR would improve patient outcome. However, it is difficult to classically compare outcome data because prospective studies, though possible, cannot accommodate the concomitantly occurring changes in the care of patients with OHCA. This will result in underpowered studies and it can even be argued that not changing out-of-hospital procedures while in-hospital improvements have shown benefit challenges the principle of equipoise. In addition, regional differences in adoption of new techniques, development, training and implementation of new procedures makes it problematic to timely and uniformly evaluate changes in the management of patients with OHCA. Therefore, we chose to descriptively report on patient outcome by implementing several adaptations aimed to optimise the chain of survival and that occurred more or less simultaneously to existing practice. The adaptations consisted of three protocolised components: bystander support by the dispatch centre, training and the use of AED for first responders and deployment of mechanical thorax compression with intubation using the Boussignac tube by ambulance staff.

The most important finding of our research is that implementation of these measures resulted in the observation that 49% of patients had ROSC at arrival at the hospital, and that the 1-year-survival rate was 27%. These figures compare favourably to the reported global survival rates at ED of 5%–20%,[12] 10% to discharge[13] and to our own historic data. We cautiously infer that the components that we implemented to optimise the chain of survival may be of benefit for patients who are resuscitated outside the hospital. There are several supporting arguments to substantiate these findings.

First, protocolised instructions reduce uncertainty and guide the initial response of non-professional bystanders. Police and/or fire departments first responders often arrive earlier than the ambulance. It is therefore considered vital to adequately train police and other first responders, which is supported by literature.[14 15] Increasing public access to AEDs and training police and other first responders in BLS and AED use are relatively simple measures to improve the outcome of resuscitation, in accordance with ERC suggestions. Indeed, it has been reported that an early start of adequate resuscitation increases higher ROSC percentages on arrival at the hospital.[15]

Second, the application of mechanical thorax compression in combination with Boussignac tube ventilation as employed in our study apparently had a positive effect on patient outcome. No major complications were found using the LUCAS and the device can be used in all common OHCA circumstances. This is in line with previous randomised studies describing similar variety and incidence of injuries comparing resuscitation using the LUCAS to manual chest compressions.[16 17] Moreover, the use of the LUCAS improves chest compressions in depth and frequency compared with manual chest compression.[18] In addition, hands-off time is reduced to a minimum as the device continuously provides thorax compressions.[19] This allows optimal management and ventilation support, enabling relatively good perfusion to organs and gas exchange as shown by higher $EtCO_2$ values[20–22] during transfer to ED.

Furthermore, the use of the LUCAS improves the safety of ambulance staff as it allows them to be securely seated while supervising the patient during transport.[23] This is supported by a survey initiated by our ambulance service which showed that ambulance staff members rated unanimously positive about using mechanical CPR (n=220). Continuity of resuscitation deemed more effective and results in a better organised management of the workplace were the mentioned contributing factors.

One drawback of using the LUCAS is that, despite use of fentanyl/midazolam, some patients showed ‘awareness signs’ with a heart rhythm incompatible with life. This is most likely explained by the fact that cerebral blood flow and cardiac output by LUCAS is significantly higher compared with manual chest compressions as described by Rubertsson in an experimental model.[24] These awareness signs can impede the quality of the resuscitation by contributing to commotion or emotional responses of bystanders and family.

Table 2 Additional descriptive event statistics

	Total n=433 no. (%)
Age, mean (range)	**64.7** year (0–100 year]
Average response time (from start call to arrival of ambulance)	**9** min (±3 min)
Tools/devices used (multiple entry)	
LUCAS	328 **(76%)**
Boussignac tube	290 **(67%)**
Endotracheal tube	32 **(7%)**
Laryngeal mask airway-Supreme	63 **(15%)**
Mask/bag	351 **(81%)**
EZ-IO intraosseous access	114 **(26%)**
None	31 **(7%)**
Awareness signs during LUCAS CPR	
None	275 *(84%)*
Any sign (multiple entry)	53 *(16%)*
Grimas face	29 *(9%)*
(Motoric) restlessness	23 *(7%)*
Trismus	13 *(4%)*
Open eyes	18 *(5%)*
Time from collapse to bystander Basic Life Support	
<1 min	**80 (27%)**
1–5 min	**136 (46%)**
6–10 min	**46 (16%)**
11–20 min	**12 (4%)**
>20 min	**20 (7%)**
No. of defibrillations on scene	
0	**172 (40%)**
1	**84 (19%)**
2	**42 (10%)**
3	**30 (7%)**
4	**19 (4%)**
5	**20 (5%)**
6 or more	**66 (15%)**
Observed suspected complications during and after LUCAS applying	
None	182 *(55%)*
Any (multiple entry)	146 *(45%)*
Excoriation sternum	85 *(26%)*
Rib fracture	46 *(14%)*
Lung secretions	18 *(5%)*
Lung bleeding (no major)	3 *(1%)*
Other	9 *(3%)*
Parameters during CPR	
SpO_2 not measurable/not measured	**231 (53%)**
SpO_2 measured	**202 (47%)**
<70%	42 **(10%)**
70%–80%	33 **(8%)**
81%–90%	36 **(8%)**
>90%	91 **(21%)**
CO_2 not measurable/not measured	**111 (26%)**
CO_2 measured	**322 (74%)**
<10 mm Hg	40 **(9%)**
10–30 mm Hg	138 **(32%)**
>30 mm Hg	144 **(33%)**
Systolic blood pressure measured	**280 (65%)**
Not measurable/not measured	**153 (35%)**
Transported to hospital	**339 (78%)**
Pronounced dead at scene	**94 (22%)**

Italic items are in comparison to subgroup totals.
Bold items are percentages and number of the total group, otherwise they are figures of subgroups.
CPR, cardiopulmonary resuscitation; LUCAS, Lund University Cardiopulmonary Assist System.

The Boussignac tube is a type of endotracheal tube in the arsenal of the ambulance service that supplies oxygenation and ventilation during CPR.[3 5 25] It further allows measurement of SpO_2 and $etCO_2$ during the resuscitation which is obviously important feedback. A positive impact on survival using appropriate ventilatory support has previously been shown to be beneficial in patients with trauma.[26] Although it is recognised that patients with trauma differ in several aspects from the population evaluated in this paper and that different techniques were employed, it confirms that adequate ventilatory support is important for the outcome of patients.

This study shows that the use of the LUCAS with or without use of the Boussignac tube fits well within the organisation of resuscitation care in practice. Nearly all the resuscitations were started (or continued) using the LUCAS. This 'hands-free' situation created using LUCAS and Boussignac tube enables to evaluate the resuscitation at an early stage and prepare for further management of the patient including diagnosis of the cause, planning and logistics.

Gender differences were observed between the proportion of patients arriving with ROSC on arrival at the ED. These findings suggest that women with an initial shockable rhythm had a better outcome than men for which we have no solid explanation as bystander CPR, arrival time of ambulance staff and use of devices did not differ between the groups.

The lower percentage ROSC at ED (35%) found using LUCAS and Boussignac during resuscitation is explained by the fact that the LUCAS and Boussignac are typically used in prolonged resuscitations. Before the LUCAS is employed, defibrillation (automated) has already taken

Table 3 ROSC at the emergency department by subgroups

n=433	Male		Female		Total	
Data name	**n=306**	**ROSC at ED**	**n=127**	**ROSC at ED**	**n=433**	**ROSC at ED**
Witnessed or unwitnessed arrest						
Witnessed	**200** *(65%)*	**107** *(54%)*	**87** *(69%)*	**53** *(61%)*	**287 (66%)**	**160** (56%)
Bystander	166 *(83%)*	87 *(52%)*	74 *(85%)*	44 *(59%)*	240 *(84%)*	131 (55%)
Ambulance	34 *(17%)*	20 *(59%)*	13 *(15%)*	9 *(69%)*	47 *(16%)*	29 (62%)
Shockable	15 *(44%)*	13 *(87%)*	8 *(62%)*	8 *(100%)*	23 *(49%)*	21 (91%)
Non-shockable	19 *(56%)*	7 *(37%)*	5 *(38%)*	1 *(20%)*	24 *(51%)*	8 (33%)
Unwitnessed	**106** *(35%)*	**40** *(38%)*	**40** *(31%)*	**14** *(35%)*	**146 (34%)**	**54** (37%)
First monitored rhythm						
Shockable	**162** *(53%)*	**102** *(63%)*	**54** *(43%)*	**42** *(78%)*	**216 (50%)**	**144** (67%)
AED	88 *(54%)*	50 (56%)	20 *(37%)*	14 (70%)	108 *(50%)*	64 (59%)
Ambulance	74 *(46%)*	52 (70%)	34 *(63%)*	28 (82%)	108 *(50%)*	80 (74%)
Non-shockable	**144** *(47%)*	**45** *(31%)*	**73** *(57%)*	**25** *(34%)*	**217 (50%)**	**70** (32%)
Bystander CPR						
Bystander CPR (multiple entry)	**225** *(74%)*	**112***(50%)*	**87** *(69%)*	**42***(48%)*	**312 (72%)**	**154** (49%)
Bystander	59	43 (73%)	11	8 (73%)	70	51 (73%)
First responders	29	12 (41%)	6	4 (67%)	35	16 (46%)
General practitioner/medical	29	15 (52%)	8	1 (13%)	36	16 (44%)
Family/friends	65	26 (40%)	31	15 (48%)	96	41 (43%)
Police	113	50 (44%)	47	21 (45%)	160	71 (44%)
With AED	150 *(67%)*	71 (47%)	48 *(55%)*	25 (52%)	198 *(63%)*	96 (48%)
Basic Life Support only	75 *(33%)*	41 (55%)	39 *(45%)*	17 (44%)	114 *(37%)*	58 (51%)
No bystander CPR	**47** *(15%)*	**15** *(32%)*	**27***(21%)*	**16***(59%)*	**74 (17%)**	**31** (42%)
Ambulance witnessed	**34** *(11%)*	**20** *(59%)*	**13** *(10%)*	**9** *(69%)*	**47 (11%)**	**29** (62%)
Lund University Cardiopulmonary Assist System and Boussignac tube	**194** *(63%)*	**66** *(34%)*	**83** *(65%)*	**30** *(36%)*	**277 (64%)**	**96** (35%)

Bold items are percentages and number of the total group, otherwise they are figures of subgroups.
AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; ED, emergency department; ROSC, return of spontaneous circulation.

place according ERC guidelines. LUCAS and Boussignac were used rarely in patients with early ROSC, which negatively impacts the percentage of patients with ROSC at ED using this combination.

CONCLUSION

Protocolised approaches including clear instructions given by the dispatch centre, an immediate start of CPR by bystanders and training given by the ambulance service to professional first responders appear to be useful additions in the chain of survival. We therefore advocate widespread implementation of these relatively easily achievable measures. Also, the use of mechanical compression using the LUCAS with concomitant Boussignac tube ventilation provides ambulance services with a simple but effective method of resuscitation. A relatively high percentage (49%) of patients with ROSC at the ED and relatively high 1-year-survival rates (27%) compared with reported global survival rates were observed using this combined method, even if no CPR was provided by bystanders. Ambulance staff members are very supportive for this device-assisted resuscitation as it appears to be effective, reduces the hands-off time and enables prolonged resuscitation. Finally, it appears that the hospital care of the patients when presented at the hospital is facilitated as the patients are already intubated and cannulated.

Further research is needed to explain the observed difference in outcomes between male and female patients. Other research efforts could be directed to investigate whether the reduced hands-off time of ambulance staff can be utilised to perform out-of-hospital interventions such as treatment of reversible causes of OHCA that were previously virtually impossible.

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