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Out-of-hospital airway management during manual compression or automated chest compression devices

A registry-based analysis

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major health problem in the USA and in Europe. Every year 275,000–420,000 people die in both of these parts of the world after such an event [1, 2]. Chest compression and ventilation are cornerstones of the cardiopulmonary resuscitation (CPR) procedure. The European Resuscitation Council (ERC) guidelines for cardiopulmonary resuscitation 2015 stated that the routine use of mechanical chest compression devices is not recommended, but they are a reasonable alternative in situations wherein sustained high-quality manual chest compressions are impractical or compromise provider safety [3]. Moreover, the ERC guidelines describe the use of an automated chest compression device (ACCD) in cases where ventricular fibrillation and/or pulseless ventricular tachycardia persist, return of spontaneous circulation (ROSC) has not been achieved or transfer to a hospital under CPR is required [3, 4]. Other reasons for the use of ACCD are prolonged CPR (e. g., hypothermia, severe hyperkalemia, anaphylaxis and pulmonary embolism), resuscitation at high altitudes (as CPR is more exhausting for the rescuer than at sea level) and during percutaneous coronary interventions (e. g., to reduce the radiation burden of the personnel). The ERC guidelines highlight the importance of preflight preparation and use of ACCD on board the helicopter emergency medical service and air ambulances if the patient is at risk of cardiac arrest during the flight [4].

In the USA, data from the cardiac arrest registry to enhance survival (CARES) registry show that 45% of participating emergency medical services (EMS) use ACCD [5]. In Europe, there has also been an increase in the use of ACCD. The three major randomized controlled trials on the use of ACCD, the CIRC [6], LINC [7] and PARAMEDIC [8] trials and other [9] did not show a benefit of ACCD over manual chest compression (mCC) in OHCA; however, they also did not reveal any profound risks or evidence of inferiority of ACCD; therefore, problems with the use of ACCD have significant implications for patient safety and are of major interest for the scientific community [10]. Data and recommendations concerning airway strategy and the compression to ventilation ratio during ACCD use on outcome of OHCA are missing [10].

The aim of this observational registry study was to review the influence of the type of airway during mCC vs. ACCD on primary outcomes after OHCA, in physician-based emergency systems.

Methods

This was a retrospective analysis of prospectively collected registry data: the German Resuscitation Registry (GRR), which was developed by the German Society for Anesthesiology and Intensive Care Medicine (Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin), is an ongoing national, prospective, multicenter registry. This registry covers 21 million inhabitants with more than 100,000 patients after OHCA. This registry is constructed in accordance with the Utstein style [11]. Patients who had an OHCA during the period 1 January 2010–30 June 2016, which occurred in any participating region and who were attended and/or treated by an EMS were eligible for inclusion in the study. Time of cardiac arrest (CA) was recorded in the database [12]. If the beginning of CA was not witnessed, the presumed onset

Authors are members of the German Resuscitation Registry Study Group.

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Table 1 Patient characteristics and outcome

	mCC				ACCD				
	All	SAD only	SAD/ETI	ETI	All	SAD only	SAD/ETI	ETI	
	n = 23,358	*n* = 4186	*n* = 2913	*n* = 16,259	*n* = 2301	*n* = 277	*n* = 396	*n* = 1628	*p*[a]
Age (mean ± SD, years)	68.9 ± 17.1	69.7 ± 16.0	68.2 ± 15.9	68.9 ± 17.6	66.1 ± 15.2	67.9 ± 13.9	64.6 ± 15.4	66.2 ± 15.4	<0.001
Age > 80 years (mean ± SD, years)	28.1	28.0	24.0	28.9	18.2	18.8	13.9	19.1	<0.001
Gender (male, %)	63.8	64.7	67.2	63.0	72.1	74.4	75.3	70.9	<0.001
Witnessed cardiac arrest (%)	45.5	42.0	48.6	45.8	52.7	52.7	53.3	52.6	<0.001
Cardiac arrest location: street/highway, doctor office (%)	20.4	18.0	23.6	20.5	28.3	26.7	31.3	27.9	<0.001
Bystander CPR (%)	32.3	34.1	38.5	30.7	36.9	37.2	39.4	36.2	<0.001
VF/VT (%)	24.2	20.9	28.8	24.3	29.6	27.8	33.8	28.9	<0.001
Cardiac origin (%)	62.8	65.6	67.1	61.3	73.0	76.9	76.5	71.5	<0.001
TCPR (%)	10.1	13.0	14.0	8.7	9.9	10.8	10.9	9.5	0.772
Vasopressor (%)	77.6	81.0	86.9	75.1	90.4	92.4	93.7	89.3	<0.001
Response time (min, mean ± SD, years)	8 ± 7	7 ± 6	7 ± 6	8 ± 7	8 ± 7	7 ± 6	8 ± 7	9 ± 7	1.000
Prehospital time interval (min, mean ± SD, years)	59 ± 20	59 ± 20	63 ± 20	58 ± 20	61 ± 20	58 ± 20	63 ± 20	60 ± 21	<0.001
TH (%)	11.8	8.5	17.4	11.7	13.0	12.3	17.9	11.9	0.091
PCI (%)	11.4	7.7	15.3	11.7	15.4	14.1	21.2	14.2	<0.001
Ever ROSC (%), 95%CI	45.6, 45.0–46.3	33.7, 32.3–35.2	56.3, 54.5–58.1	46.8, 46.0–47.6	42.8, 40.8–44.6	34.3, 28.7–40.2	44.9, 40.0–50.0	43.7, 41.3–46.2	0.01
Hospital admission, ROSC (%)	39.2	26.7	47.0	41.0	27.2	15.9	27.8	29.0	<0.001
Hospital admission, Ongoing CPR (%)	8.3	7.0	8.6	8.7	38.6	35.4	46.0	37.3	<0.001
Hospital discharge (%)	10.6	5.6	10.3	12.0	6.8	5.8	6.6	7.0	<0.001
Hospital discharge, CPC 1,2 (%)	7.9	3.7	7.3	9.1	4.7	3.6	5.1	4.9	<0.001
Predicted RACA ROSC rate (%)	42.2	38.7	44.0	42.8	45.7	43.1	47.1	45.8	<0.001
Delta RACA	3.398	−4.970	12.259	3.965	−2.908	−8.757	−2.126	−2.126	–

mCC manual chest compressions, *SAD* supraglottic airway device, *ETI* endotracheal intubation, *VF/VT* ventricular fibrillation/ventricular tachycardia, *TH* therapeutic hypothermia, *PCI* percutaneous coronary intervention, *CPR* cardiopulmonary resuscitation, *CPC* cerebral performance categories, *ROSC* Return of Spontaneous Circulation, *RACA* Return of Spontaneous Circulation after Cardiac Arrest, *TCPR* (dispatcher assisted) telephone cardiopulmonary resuscitation, *TH* therapeutic hypothermia

[a]mCC all vs. ACCD all

time of CA was documented. If rescuers on the scene did not consider trauma, submersion, drug overdose, asphyxia or exsanguination as causes of the CA, a cardiac etiology was adopted. Moreover, the time interval between CA and start of chest compression was analyzed. The patient characteristics included age and gender, shockable rhythm (e. g., ventricular fibrillation and pulseless ventricular tachycardia), dispatcher-assisted telephone CPR, witnessed arrest, bystander CPR, and vasopressor use were recorded.

At first, the type of out-of-hospital airway used was divided into supraglottic airway devices (SAD only), endotracheal tubes (ETI), and patients initially treated with SAD, which were thereafter changed into endotracheal tubes (SAD/ETI) during the out-of-hospital course. Patients treated only with bag-mask ventilation in the out-of-hospital setting were excluded. For these groups, further stratification was done concerning patients treated (1) only with mCC or (2) with ACCD. Because the combination of mCC with ETI is the gold standard, this group was used as the reference group. Primary outcome was recorded as ROSC, ongoing CPR at hospital admission, ROSC at hospital admission, survival to hospital discharge, and cerebral performance categories (CPC) 1,2 in patients who survived to hospital discharge.

Abstract · Zusammenfassung

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Out-of-hospital airway management during manual compression or automated chest compression devices. A registry-based analysis

Abstract

Background. Airway management during resuscitation is pivotal for treating hypoxia and inducing reoxygenation. This German Resuscitation Registry (GRR) analysis investigated the influence of the type of airway used in patients treated with manual chest compression (mCC) and automated chest compression devices (ACCD) after out-of-hospital cardiac arrest (OHCA).

Methods. Out of 42,977 patients (1 January 2010–30 June 2016) information on outcome, airway management and method of chest compressions were available for 27,544 patients. Hospital admission under cardiopulmonary resuscitation (CPR), hospital admission with return of spontaneous circulation (ROSC), hospital discharge and discharge with cerebral performance categories 1 and 2 (CPC 1,2) were used to compare outcome in patients treated with mCC vs. ACCD, and classified by endotracheal intubation (ETI), initial supraglottic airway device (SAD) changed into ETI, and only SAD use.

Results. Outcomes for hospital admission under ongoing CPR, hospital admission with ROSC, hospital discharge and neurologically intact survival (CPC 1,2) for mCC (84.8%) vs. ACCD (15.2%) groups were: 8.4/38.6%, 39.2/27.2%, 10.6/6.8%, 7.9/4.7% ($p < 0.001$), respectively. Only mCC with SAD/ETI for ever ROSC (OR 1.466, 95% CI: 1.353–1.588, $p < 0.001$) and mCC group with SAD/ETI for hospital admission with ROSC showed better outcomes (odds ratio [OR] 1.277, 95% confidence interval [CI]: 1.179–1.384, $p < 0.001$) in comparison to mCC treated with ETI. Compared to mCC/ETI, all other groups were associated with a decrease in neurologically intact survival.

Conclusion. Better outcomes were found for mCC in comparison to ACCD and ETI showed better outcomes in comparison to SAD only. This observational registry study raised the hypothesis that SAD only should be avoided or SAD should be changed into ETI, independent of whether mCC or ACCD is used.

Keywords

Manual chest compression · Automated chest compression device · Supraglottic airway device · Endotracheal intubation · Outcome

Prähospitales Atemwegsmanagement während der manuellen oder der mit automatischen Reanimationshilfen durchgeführten kardiopulmonalen Reanimation. Eine Registeranalyse

Zusammenfassung

Hintergrund. Das Atemwegsmanagement während der kardiopulmonalen Reanimation (CPR) ist für die Behandlung einer Hypoxie essentiell und soll zu einer Reoxygenierung führen. In der vorliegenden Analyse des Deutschen Reanimationsregisters sollte daher der Einfluss des genutzten Atemwegs auf das Überleben bei manuellen (mCC) und automatisch gestützten Thoraxkompressionen (ACCD) bei Patienten mit prähospitalen Herzkreislaufstillstand (OHCA) untersuchen werden.

Material und Methoden. Aus seiner Gesamtkohorte von 42.977 Patienten (01.01.2010–30.06.2016) lagen die Informationen Behandlungsergebnis, durchgeführtes Atemwegsmanagement und Art der durchgeführten Thoraxkompressionen in 27.544 Fällen vor. Die Krankenhausaufnahme unter fortgesetzter Reanimation bzw. Wiedereintritt eines Spontankreislaufes (ROSC) und die Krankenhausentlassung mit einem guten neurologischen Ergebnis (CPC 1,2) wurde genutzt, um das Behandlungsergebnis von Patienten mit mCC und ACCD, klassifiziert nach endotrachealer Intubation (ETI), initial supraglottischen Atemweg (SGA) mit Wechsel auf Intubation, und der alleinigen Anwendung von SGA, zu untersuchen.

Ergebnisse. Die Krankenhausaufnahme unter fortgesetzter Reanimation, die Krankenhausaufnahme im ROSC, die Krankenhausentlassung und Krankennhausentlassung mit gutem neurologischen Ergebnis (CPC 1,2) für mCC (84,8 %) vs. ACCD (15,2 %) betrug: 8,4/38,6 %, 39,2/27,2 %, 10,6/6,8 %, 7,9/4,7 % ($p < 0{,}001$). Nur die Gruppe mit mCC und SGA/ETI für jemals ROSC (OR 1,466, 95 % CI: 1,353–1,588, $p < 0{,}001$) und die mCC Gruppe mit SGA/ETI für Krankenhausaufnahme im ROSC zeigte ein besseres Überleben (OR 1,277, 95 % CI: 1,179–1,384, $p < 0{,}001$) im Vergleich zur Referenzgruppe mCC mit ETI. Im Vergleich zu der Gruppe mCC/ETI wiesen alle anderen Gruppen ein schlechteres neurologisches Behandlungsergebnis auf.

Schlussfolgerung. Ein besseres Behandlungsergebnis als ACCD zeigte mCC. Ein besseres Behandlungsergebnis als alleinige SGA-Anwendung zeigte ETI. Diese beobachtende Registerstudie unterstützt die Hypothese, dass sowohl bei mCC als auch bei ACCD gestützten Thoraxkompressionen die alleinige Anwendung von SGA vermieden, und dass SGA in eine endotracheale Intubation überführt werden sollten.

Schlüsselwörter

Manuelle Thoraxkompressionen · Automatische externe Thoraxkompressionen · Supraglottische Atemwege · Endotracheale Intubation · Behandlungsergebnis

The ROSC after cardiac arrest (RACA) score was calculated as published elsewhere [13] and is a multivariate logistic regression model and provides the probability of ROSC. The score is developed as a generally applicable tool to predict the initial resuscitation success using different independent variables and confounders (e. g., age, gender, etiology of CA, witnessing by laypeople or professionals, location of CA, initial rhythm, bystander CPR and time to first vehicle stops; [13, 14]) that are easy to assess after arrival of the EMS. Mean observed ROSC (95% confidence interval) is compared with predicted ROSC (RACA). The RACA score can be used as an instrument to compare different EMS systems, and may help to assess effects of different resuscitation strategies [13].

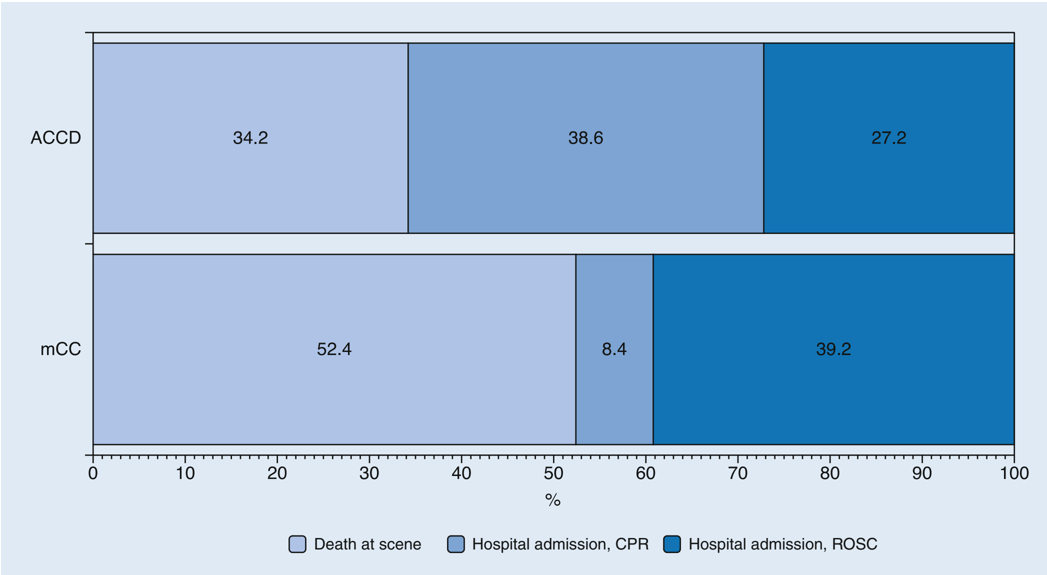

Fig. 1 ◄ Outcome of out-of-hospital cardiac arrest patients in the manual chest compression (mCC, $n = 23{,}358$) and automated chest compression device (ACCD, $n = 2301$) group

This study was approved by the ethics committee of the University of Kiel, Faculty of Medicine (register number D469/17).

Statistical analysis

Data were processed using EXCEL XP (Microsoft Corporation, Redmond, WA), and statistical analyses used IBM SPSS Statistics for Windows (IBM Corp version 20.0. Armonk, NY). Categorical data were analyzed with χ^2-tests. Values for parametric data are given as means with standard deviations. Continuous data were analyzed using a one-way ANOVA and p-values ≤ 0.05 were considered statistically significant. Response time is given in minutes and seconds. For comparison of observed ROSC and predicted RACA-ROSC rate, the delta RACA-ROSC was calculated and the 95% confidence interval of observed ROSC rate and the calculated mean of predicted RACA-ROSC was used. A statistical significance ($p < 0.05$) is given, if the predicted ROSC rate is not within the 95% confidence interval (95% CI) of the observed ROSC rate.

Results

During the study period from 1 January 2010 to 30 June 2016 a total of 42,977 patients with OHCA and CPR were included in the GRR. All relevant and complete data were available from 27,544 patients (64.1%), defined as the study cohort. Out of these patients, 23,358 (84.8%) were treated with mCC and 2,301 with ACCD (15.2%). While comparable patients in both groups were treated with ETI (69.6 vs. 70.8%, $p = 0.260$), in the mCC group SAD only was more common than in the ACCD group (17.9 vs. 12.0%, $p < 0.001$), and the airway was changed from SAD to ETI (SAD/ETI: 12.5 vs. 17.2%, $p < 0.001$) in less mCC patients in the out-of-hospital setting (**Table 1**).

Demographics and patient characteristics

An overview of the patient characteristics of mCC and ACCD patients, and the subgroups according to the airway devices used is given in **Table 1**. We observed significant differences between the groups: patients in the ACCD groups seemed to be younger, more likely to be male, have a witnessed VF arrest and receive bystander CPR.

Outcome

The ever ROSC rate was higher in the mCC in comparison to the ACCD group (45.6 vs. 42.8%, $p < 0.01$). While more patients were declared dead at the scene in the mCC group (52.4 vs. 34.2, $p < 0.001$), more patients were admitted under ongoing chest compressions in the ACCD group (8.4 vs. 38.6, $p < 0.001$; **Figs. 1 and 2**). Patients treated with SAD only in the mCC and ACCD groups suffered from the lowest hospital admission rate with ROSC (26.7 and 15.9%), lowest survival rate to hospital discharge (5.6 and 5.8%), and lowest survival rate to hospital discharge with good neurological outcome (CPC 1,2) with 3.7% and 3.6%, respectively, in comparison to all other airway and compression strategies (**Figs. 2 and 3**). In comparison to the mCC group treated with ETI, only patients in the mCC group with SAD/ETI for ever ROSC (odds ratio [OR] 1.466, 95% confidence interval [CI]: 1.353–1.588, $p < 0.001$), and patients in the mCC group with SAD/ETI for hospital admission with ROSC showed better outcomes (OR 1.277, 95% CI: 1.179–1.384, $p < 0.001$). In comparison to the mCC group with ETI, all other compression and airway strategies were associated with a significant decrease in neurologically intact survival (**Fig. 3**). The comparison of ever ROSC rate, RACA ROSC rate as well as the delta RACA ROSC showed the best survival for patients with a change from SAD to ETI in the mCC group and for patients with ETI in the ACCD group (**Fig. 4a, b**). The highest survival and CPC1/2 rates were detected with mCC and ETI without SAD (12.0% and 9.1%, respectively).

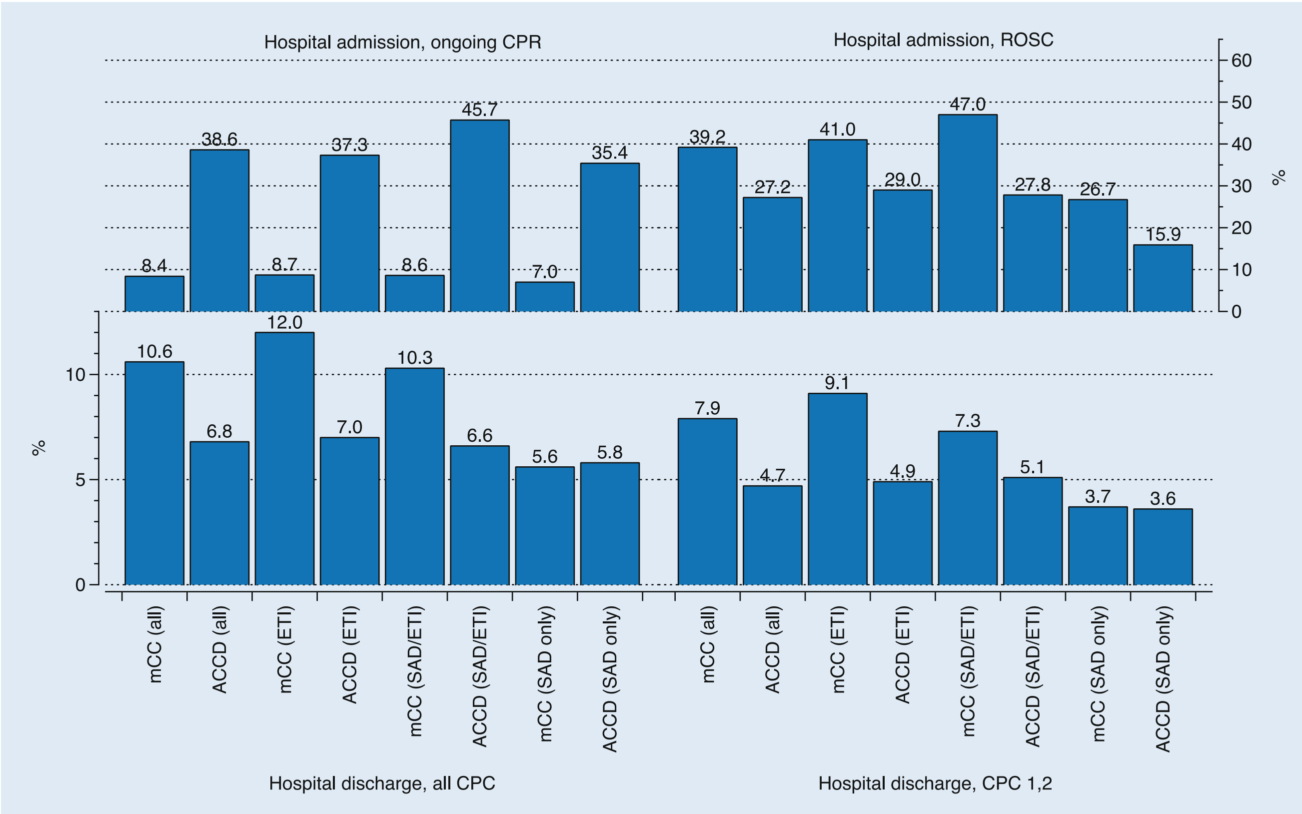

Fig. 2 ▲ Outcome of out-of-hospital cardiac arrest patients in the manual chest compression (mCC, $n = 23{,}358$) and automated chest compression device (ACCD, $n = 2301$) groups stratified by airway management strategy (*ETI* endotracheal tube, *SAD* supraglottic airway device, *CPC* cerebral performance category)

Discussion

This study of the GRR registry demonstrated for the first time a significant difference between the outcomes of OHCA patients treated with mCC or ACCD, stratified by the airway used in the out-of-hospital setting. The most important finding of our study was that patients treated with SAD alone during mCC and ACCD in OHCA showed the lowest survival rates to hospital discharge and the lowest survival rate with good neurological outcome in comparison to all other airway and compression strategies.

Advanced airway management, such as ETI or SAD, is one of the most prominent interventions in OHCA treatment. In the past, some studies investigated the pitfalls and limitations of ETI, including unrecognized misplacement and dislodgement, multiple failed ETI attempts, and interruption of chest compression continuity [15–18]. The ERC guidelines discussed the airway strategy according to the skill level and stated that there are no data supporting the routine use of any specific approach to airway management during cardiac arrest [3]. Recently published studies tended to use an observational design with the well-known methodological flaws, and it was stated that large-scale randomized trials are required to solve ongoing uncertainty in this area of clinical practice [19]. Our findings were in line with the recently published results from Sulzgruber et al. [20]. The authors used a propensity score matched analysis and found significant outcome differences between different airway strategies (including laryngeal tube and ETI) during OHCA treatment. Another recently published cluster randomized study compared i-gel vs. laryngeal mask airway supreme vs. current practice (principally tracheal intubation) and found no significant differences in outcome between the three groups [21]; however, the study was a feasibility study and declared by the authors to be underpowered to detect survival differences. In line with our study, a meta-analysis of 10 studies including 34,533 ETI and 41,116 SAD treated OHCA patients found that patients who receive ETI by EMS are more likely to obtain ROSC, survive to hospital admission, and survive neurologically intact when compared with SAD [22]. Additionally, another analysis of the cardiac arrest registry to enhance survival (CARES) registry compared the outcomes of 5591 patients treated with ETI and 3110 patients with SAD found that survival was higher among OHCA receiving ETI than receiving SAD [15]. Altogether, these results provide further data to support ETI as the gold standard during OHCA; however, the previously mentioned studies did not take into account the type of chest compressions (manual vs. automated) provided during cardiac arrest.

The recently published guidelines on CPR from the ERC highlighted the importance of high-quality chest compres-

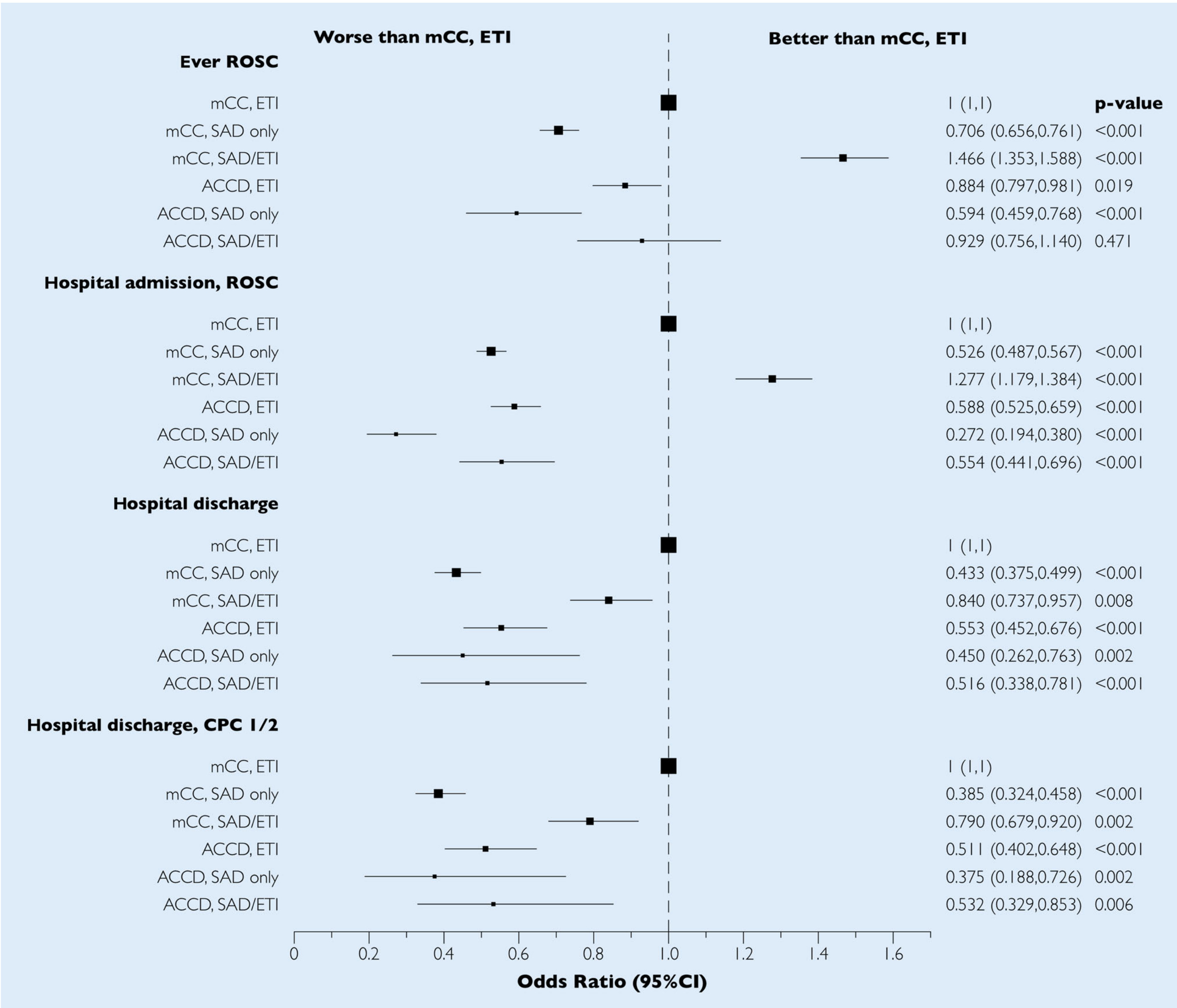

Fig. 3 ▲ Analyses of outcomes ever ROSC, hospital admission with ROSC, survival to hospital discharge and survival to hospital discharge with CPC 1/2 as odds ratio with 95% confidence interval (*CI*) adjusted to mCC, ETI (*ETI* endotracheal tube, *SAD* supraglottic airway device, *CPC* cerebral performance category, *mCC* manual chest compression, *ACCD* automated chest compression device)

sions [3, 4]. The use of ACCD during CPR of OHCA patients may to be associated with some advantages: minimization of interruptions, constant compression depth and high compression ratio. Despite the fact that the three major randomized controlled trials on the use of ACCD (CIRC [6], LINC [7] and PARAMEDIC [8]) did not show a benefit of ACCD over mCC in OHCA, no profound risks or evidence of inferiority of ACCD in comparison to mCC were found. These previous findings were not in line with the findings of the presented GRR study showing that the outcomes of OHCA patients who received mCC were significantly better in comparison to patients who received ACCD.

Several confounders have the potential to influence these results. One of the confounders may be the airway and ventilation strategy. Thereby, the current guidelines do not address specific ventilation problems with ACCD. The recommendations made in 2005, 2010 and 2015 by the ERC concerning the compression-to-ventilation ratio before and after advanced airway management are identical [3, 23, 24].

1. A compression to ventilation ratio of 30:2 before intubation/supraglottic airway device and uninterrupted chest compression after intubation or use of supraglottic airway device as airway strategy.
2. Once a SAD has been inserted, uninterrupted chest compressions should be attempted; if excessive gas leakage causes inadequate ventilation, chest compressions should be interrupted to enable ventilation (using a compression to ventilation ratio of 30:2).

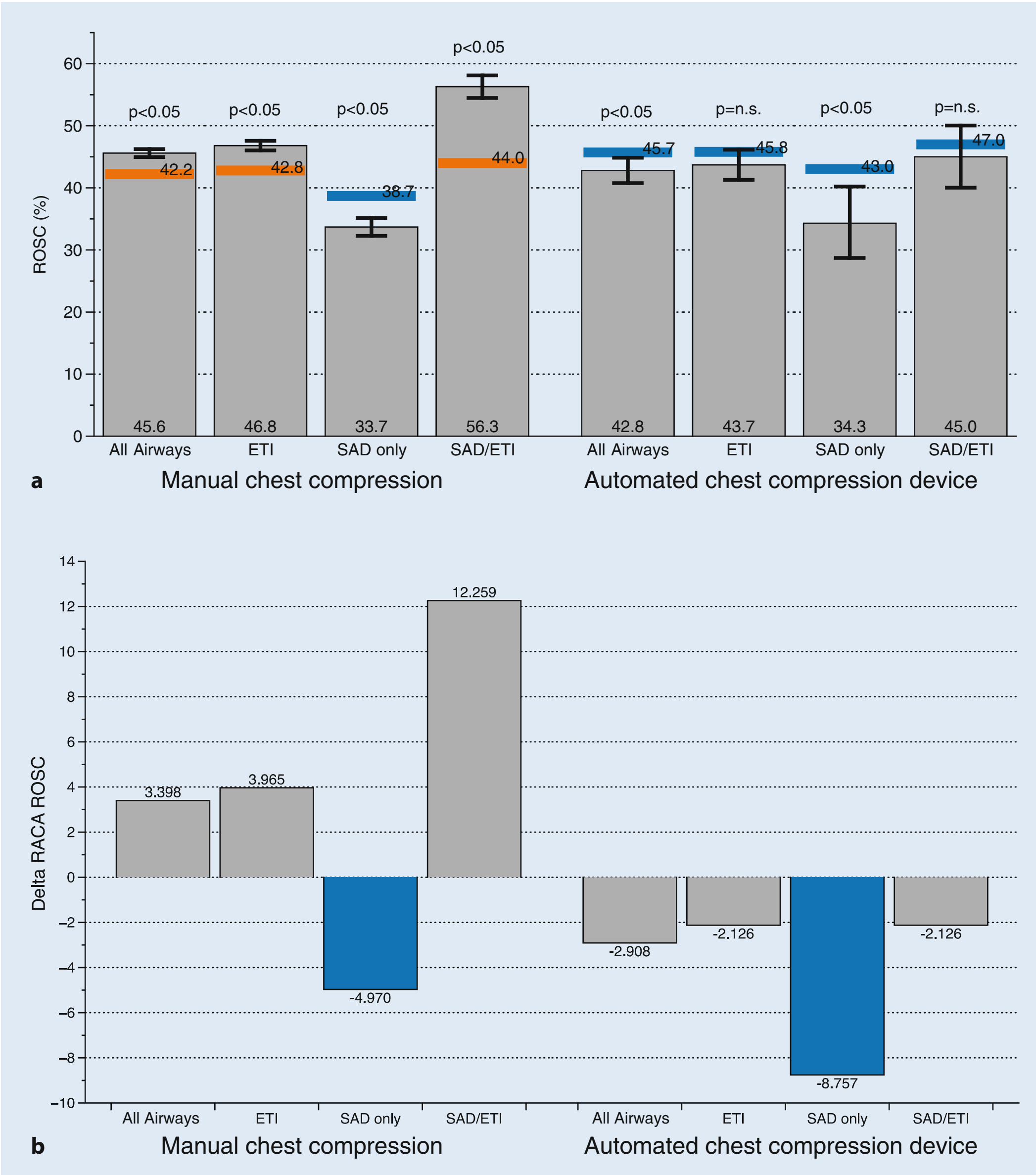

Fig. 4 ◄ **a** Effect of airway management and type of chest compressions on outcome. Grey columns represent the recorded ROSC rates. Error bars represent 95% confidence interval (CI). *Orange bars* showed that the recorded ROSC rate was higher than the predicted RACA ROSC rate. *Blue bars* show that the recorded ROSC rate was lower than the predicted RACA ROSC rate (*ETI* endotracheal tube, *SAD* supraglottic airway device). **b** Delta RACA score in the manual chest compression (mCC, $n = 23{,}358$) and automated chest compression device (ACCD, $n = 2301$) group stratified by airway management strategy (*ETI* endotracheal tube, *SAD* supraglottic airway device)

Notably, and not surprisingly given the general lack of evidence, no special recommendations were made regarding the use of SAD during ACCD. There is a lack of data to support the safety and effectiveness of the recommendation for uninterrupted chest compression using ACCD and ventilation in combination with SAD. There is insufficient or missing evidence for the effectiveness of any airway and ventilation strategy and the use of ACCD.

In the presented GRR study we did not investigate the compression to ventilation ratio used in the OHCA patients stratified according to the airway device used; however, to the best of our knowledge, there are no clinical studies that focus on effective oxygenation and elimination of carbon dioxide in patients suffering from OHCA who are treated with ACCD. Furthermore, there is a notable lack of data on upper airway pressure limits (e. g., avoidance of barotrauma) during mCC. During ACCD airway pressure may exceed 20 cmH_2O, which can make ventilation using SAD ineffective. This may be the reason for the observed lowest survival rate and neurological outcome in OHCA patients treated with SAD only in comparison to all other airway strategies in the present investigation. Although not investigated in the present study, ventilation problems might occur in the setting of SAD use during ACCD. In the authors' clinical experience, ACCD makes continuous high-quality ventilation difficult and sometimes impossible [10]. None of the available ACCD cited in the ERC guidelines were constructed with particular regard to effective and safe ventilation [3].

In general, the use of a SAD itself can be complicated by numerous problems that lead to inadequate ventilation, hypoxemia and hypercapnia (e. g., displacement, leakage, incorrect placement and tongue/pharyngeal swelling; [25, 26]). As chest compression alone without oxygenation and ventilation are recommended only for the brief time period of basic life support performed by lay persons (compression-only CPR), a safe strategy for airway management and ventilation is an integral part of any resuscitative measures [3, 27]. After the arrival of healthcare professionals (e. g., paramedics and EMS physicians) and during advanced life support, ensuring oxygenation and elimination of carbon dioxide is crucial, even if the optimal strategy for managing the airway has not yet been determined [19]. In this context, our findings showed that a SAD first strategy (e. g. mCC, SAD/ETI) may be beneficial resulting in the mCC group to the best results for delta RACA ROSC. High-quality chest compressions only, with and without ACCD, will remain unsuccessful without oxygenation and decarboxylation of the blood. Desaturated blood does not contribute to myocardial and cerebral reoxygenation, and hypercapnia may be detrimental (e. g. acidosis and cardio-depressive effects; [28]).

During ventilation with SAD, perceived as a secured airway according to the ERC guidelines [3], while using ACCD there is considerable potential for ineffective ventilation with continuous and uninterrupted ACCD chest compression. It can be hypothesized that SAD was not so effective for securing the airway during CPR as expected and that SAD should be perceived as an unsecured airway. Thus, it is conceivable that the results of the three major ACCD trials (CIRC [6], LINC [7] and PARAMEDIC [8]) may reveal a significant difference between the study arms if patients ventilated with a bag-valve mask or SAD were excluded from the analysis. We presume that, particularly with SAD and continuous ACCD, ventilation is ineffective and a significant confounder in the three mentioned major ACCD studies. This may be particularly important for patients transported to a hospital with prolonged and ongoing CPR during transport as recommended by the current ERC guidelines [3]. Interestingly, in the presented registry study more patients in the ACCD group were admitted under ongoing chest compression. This may be consequence of the ERC recommendations to use an ACCD during patient transport due to safety reasons while transportation under mCC is associated with high risk and less often high-quality chest compressions. Keeping these findings in mind, we suggest an extended raw data analysis of the three major ACCD trials with respect to the impact of ACCD on effective ventilation. We hope that this will lead to better recommendations on safe and effective airway management and ventilation strategies during the use of ACCD, regarding, in particular, the use of SAD in these patients.

Limitations

First at all, this was a retrospective observational study and thus we can only identify association rather than causation. We report on registry data with all known limitations of these conditions but the reported case load is similar to the results of the randomized controlled trials comparing mCC and ACCD (CIRC [6], LINC [7] and PARAMEDIC [8]); however, due to the registry nature of the study we did not record the quality of mCC. Moreover, there are differences in patient characteristics among the groups, and this may be due to a systematic bias because only certain providers may have access to ACCD or SAD. A major limitation of this registry study is that we did not know the type of SAD (e. g., laryngeal tube, laryngeal mask) and the reason for its use (e. g., primary airway vs. secondary airway strategy after failed ETI). Additionally, we did not know when the SAD was changed into an ETI in the out-of-hospital setting, and what the reason was for using SAD (e. g., difficult airway management). Furthermore, we did not know the type of ACCD and when und how long this device was used. Additionally, the GRR did not document the timing of chest compressions and airway management; recently published studies stated this is important [29, 30]; however, the out-of-hospital time interval was nearly the same in the mCC and ACCD groups. In this study major surrogate parameters for successful airway management and ventilation are not reported: oxygen saturation (S_aO_2) and arterial carbon dioxide (p_aCO_2) at hospital admission. These values may be of major importance in order to verify the success of a chosen airway and ventilation strategy. Further prospective studies comparing the airway and ventilation strategy in mCC and ACCD are essential.

Conclusion

In this registry study, mCC showed better survival rates and better neurological outcomes in comparison to ACCD in OHCA. In both groups, out-of-hospital airway management using ETI showed better outcomes in comparison to SAD only. This observational registry study raised the hypothesis that in OHCA patients, SAD only should be avoided or SAD should be changed into ETI, independent of whether mCC or ACCD is performed.

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Compliance with ethical guidelines

Conflict of interest. M. Bernhard, N. H. Behrens, J. Wnent, S. Seewald, S. Brenner, T. Jantzen, A. Bohn, J. T. Gräsner and M. Fischer declare that they have no competing interests.

This study was approved by the ethics committee of the University of Kiel, Faculty of Medicine (register number D469/17).

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