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Effect of video laryngoscopy for non-trauma out-of-hospital cardiac arrest on clinical outcome: A registry-based analysis

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Abstract

Aim: Videolaryngoscopy (VL) is a promising tool to provide a safe airway during cardiopulmonary resuscitation (CPR) and to ensure early reoxygenation. Using data from the German Resuscitation Registry, we investigated the outcome of non-traumatic out-of-hospital cardiac arrest (OHCA) patients treated with VL versus direct laryngoscopy (DL) for airway management.

Methods: We analysed retrospective data of 14,387 patients from 1 January 2018 until 31 December 2021 (VL group, *n* = 2201; DL group, *n* = 12186). Primary endpoint was discharge with cerebral performance categories one and two (CPC1/2). Secondary endpoints were the rate of return of spontaneous circulation (ROSC), hospital admission, hospital admission with ongoing cardiopulmonary resuscitation, 30-day survival/ hospital discharge and airway management complications. We used multivariate binary logistic regression analysis to identify the effects on outcome of known influencing variables and of VL vs DL.

Results: The multivariate regression model revealed that VL was an independent predictor of CPC1/2 survival (OR = 1.34, 95% CI = 1.12–1.61, p = 0.002) and of hospital discharge/30-day survival (OR = 1.26, 95% CI = 1.08–1.47, p = 0,004).

Conclusion: VL for endotracheal intubation (ETI) at OHCA was associated with better neurological outcome in patients with ROSC. Therefore, the use of VL for OHCA offers a promising perspective. Further prospective studies are required.

Keywords: Airway management, Video laryngoscopy, Cardiopulmonary resuscitation, Endotracheal intubation, Out-of-hospital cardiac arrest, German Resuscitation Registry, Multivariate logistic regression model

Introduction

Appropriate airway management is one of the most important procedures during advanced life support and is essential for the adequate ventilation of the patients. Appropriate ventilation, improved oxygenation and the avoidance of aspiration are important factors for the return of spontaneous circulation (ROSC) and for good neurological outcome of a patient undergoing cardiopulmonary resuscitation (CPR).[1–2] Reduced hypoxia during CPR is associated with improved survival.[3]

Abbreviations: CPC, cerebral performance category, CPR, cardiopulmonary resuscitation, DL, direct laryngoscopy, EMS, emergency medical services, ETI, endotracheal intubation, GRR, German Resuscitation Registry, OHCA, out-of-hospital cardiac arrest, PES, pre-emergency status, ROSC, return of spontaneous circulation, SGA, supraglottic airway, VF, ventricular fibrillation, VL, video laryngoscopy, VT, ventricular tachycardia

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VL improves first-pass success in ETI during CPR among novice physicians[4] and specialised paramedics.[5] A recently published retrospective study also based on data from the German Resuscitation Registry (GRR) shows that first-pass success is associated with a higher chance of ROSC.[6] On the other hand a recently published study with registry data from more than 22,000 patients in the USA with non-physician-assisted EMS was not able to show a correlation between improved overall first-pass effect and the ROSC rate.[7–8] Secondary analyses of the PART trial showed that first-pass success had higher ROSC rates but was not associated with any other outcomes.[9] Another advantage of VL for intubation during CPR may be reduced interruptions of chest compressions and therefore potentially improving outcome.[10]

To the best of our knowledge, there are no studies in a physician-staffed EMS system with sufficient case numbers for investigating the impact of VL in resuscitation with regard to neurological outcome and ROSC rates. The subject of this study was therefore a comparison between VL and DL in terms of clinical outcome in resuscitation based on a data analysis of the GRR.

Methods

German EMS system and German resuscitation registry

The EMS system in Germany has special features, in contrast to other EMS systems worldwide. The German system is based on a two-tiered system with paramedic-staffed ambulance cars and additional emergency physician-staffed response vehicles in all life-threatening cases. All patients are treated by the paramedics and emergency physician together at the scene of an OHCA, but if an ETI is needed it is usually performed by the emergency physician.

The GRR is a nationwide, multicentre registry that represents the entire rescue chain from resuscitation to hospital discharge.[11–13] Data collection by the GRR is voluntary and takes place anonymously. Data are entered by emergency physicians or emergency service personnel and by the attending physicians in the clinic. The data are usually released by the medical directors of the EMS or by persons assigned by them. The GRR is organised and funded by the German Society of Anaesthesiology and Intensive Care Medicine. All participating EMS and clinics pay an annual fee.

Patients

Since the start of recording VL in the registry in 2006, 56,875 OHCA patients from EMS systems with reference status have been recorded in the GRR up to 31 December 2021. Participating EMS systems with reference status have a high reliable data entry quality compared to other participating EMS systems in the GRR.[11–13] Our retrospective cohort study was based on anonymised patient data from the GRR for the period 1 January 2018 to 31 December 2021. Although VL had been introduced from 2006 onwards, it became broadly available and gained higher acceptance during recent years. The reported proportion of VL for ETI at OHCA in the registry has only been stable at over 10% since 2018–2021. For the study period, routine use in the field can be assumed.

All adult prehospital patients who underwent OHCA were included. Treatment at the OHCA had to include an ETI with VL or DL.

Exclusion criteria were age under 18 years, trauma as a suspected aetiology, supraglottic airway (SGA) as the only airway access, change of procedure in airway management (e.g., SGA and later ETI; ETI inefficient and later SGA; or switch to mask ventilation) and declaration of death at the scene without CPR taking place. The latter are also registered in the GRR.

The primary endpoint was discharge with good neurological outcome, namely, cerebral performance categories one and two (CPC1/2).

Secondary endpoints were the ROSC rate (any ROSC), hospital admission with ROSC, hospital admission with ongoing resuscitation, 30-day survival or hospital discharge, and difficult airway management (more than one attempt at ETI, frequency of cricothyrotomy).

Statistical analysis

After application of the inclusion and exclusion criteria, baseline data were derived and the VL and DL groups at OHCA were compared. First, a univariate analysis of the outcome data was performed. Then the entire cohort was analysed using a multivariate logistic regression model for the primary endpoint of discharge with CPC1/2 and the secondary endpoint of hospital discharge or 30-day survival. Variables for the multivariate logistic regression analysis were derived from other trials or previous studies of the same registry and showed a significant effect on the outcome in each case. Therefore, the following variables were included:

- age with reference category patients “age group <= 60 years” tested against age groups with higher age (<=70 years, <= 80 years, <= 90 years, >= 91 years),[14–19]
- pre-emergency status (PES: used to classify the physical status of every patient prior to their OHCA; 1 = no pre-existing disease, 2 = disease without impairment, 3 = disease with impairment, 4 = disease with severe impairment as a constant threat to life, 5 = dying patient not expected to survive the next 24 h) with reference category “no pre-existing disease” (PD) tested against all other status groups and a group of unknows PES,[14–15,17,20]
- initial ECG rhythm with reference category “VF/ VT” tested against “PEA” or “Asystole”,[14–15,17–20]
- arrest witnessed by emergency medical team or arrest witnessed by bystander with reference category “not witnessed/unknown” tested against “witnessed”,[14–15,17–20]
- bystander CPR with reference category “bystander CPR not performed/unkown” tested against “bystander CPR performed”,[14–15,17–20]
- presumed aetiology (cardiac/unknown and hypoxic) with reference category “all others” tested against “cardiac/ unknown” and “all others” tested against “hypoxic”,[15,17–20]
- place of OHCA (Physician’s office, nursing home, working place, school, sports, public place or home) with reference category “home/others/unknown” tested against “nursing home”, “working place/school/sports”, “physician’s office” and “public place”,[14–15,17–18,20–21]
- categories of applied adrenaline (epinephrine) as an established surrogate parameter for the duration of CPR with reference category “no adrenaline” tested against five adrenaline dose groups and a group of “unknows adrenaline dose, when adrenaline given”,[15,17,20]
- and use of VL, as the only true therapeutic confounder in our binary logistic regression MV model, with reference category “VL not used/unknown” tested against “VL used”.

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Other therapeutic confounders, such as the administration of amiodarone, i.o. or i.v. access or the use of mechanical chest compression systems, were not considered as confounders in our MV model, as they usually occur after ETI and may therefore cause bias as mediators.

Groups were compared using chi-square (x^2) or the *t*-test for non-categorical data for two independent samples and $p < 0.05$ was considered statistically significant. Values for parametric data were given as means with standard deviations. Continuous data were analysed using Student's *t*-test, The x^2 test was used to compare categorical data. Categorical variables were expressed as percentages and as an odds ratio (OR) with 95% confidence interval (95% CI). As a measure of explained variation, Nagelkerke's R^2 was used. Data were processed using Excel software (Version 2017, Microsoft Corporation, Redmond, WA, USA) and IBM SPSS Statistics (Version 27.0, IBM Corporation, Armonk, NY, USA).

Results

A total of 14,387 patients were included in the primary analysis (Fig. 1), with 2201 in the VL group and 12,186 in the DL group. Mean age was 68.94 (SD ± 15.04) years in the VL group and 69.85 (SD ± 14.82) years in the DL group, with 1480/2201 (67.2%) in the VL group and 8151/12,186 (66.9%) in the DL group being male. The rate of ETI carried out by EMS physicians [2188/2201 (99.4%) versus 11,920/12,186 (97.8%); $p < 0.001$] was significantly higher in the VL group. With difficult airway management complications, the rate of multiple attempts for ETI [408/2201 (18.5%) versus 1139/12,186 (9.3%); $p < 0.001$] and the cricothyrotomy rate [8/2201 (0.4%) versus 13/12,186 (0.1%); $p < 0.006$] were also significantly higher in the VL group. In addition, rates of use of intravenous and intraosseous access, adrenaline and mechanical resuscitation devices were significantly higher in the VL group. Primary asystole

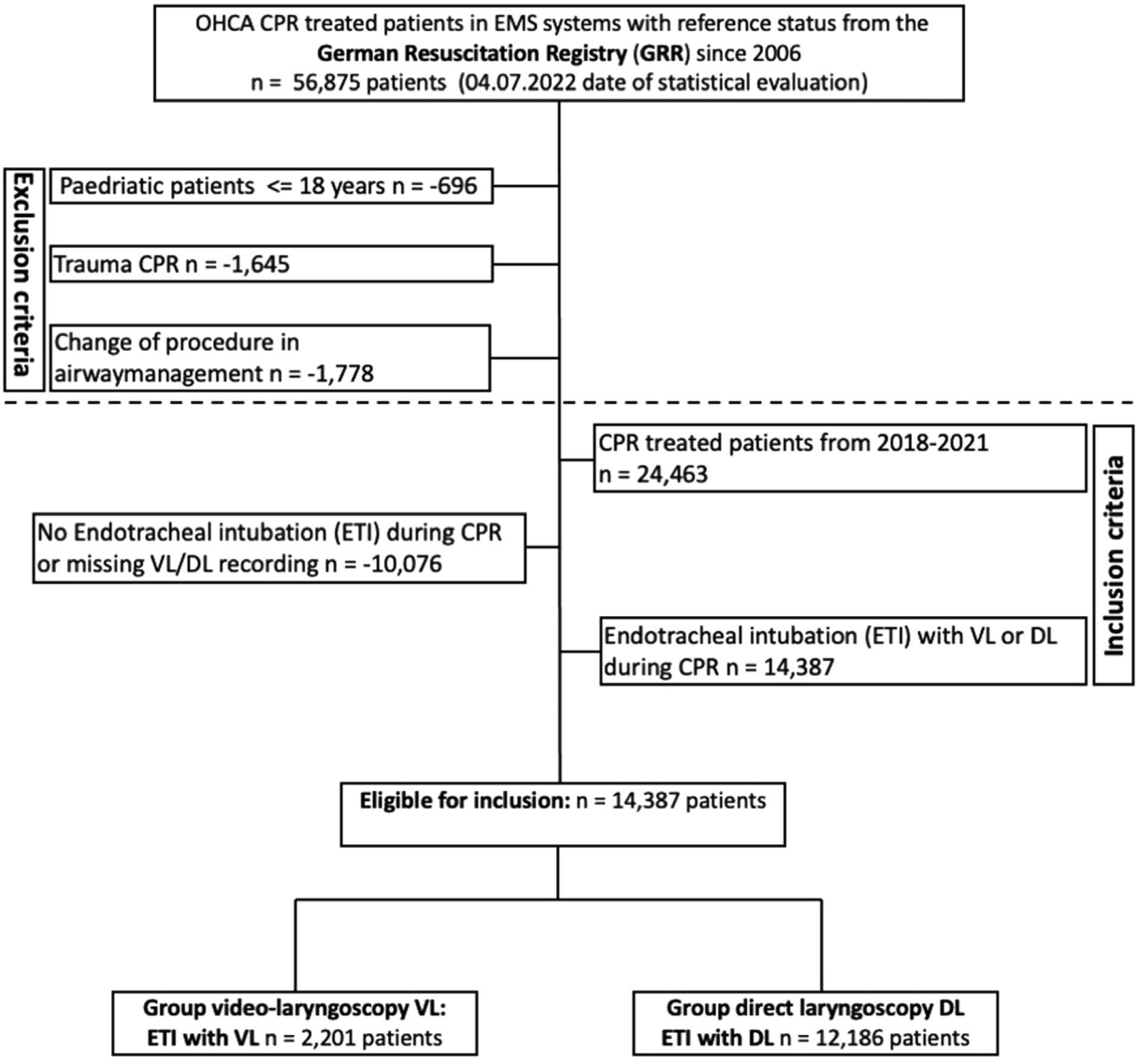

Fig. 1 – Patient selection flow chart.

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was reported more often in the DL group. All remaining parameters showed no significant difference between the two groups (Table 1).

Regarding outcome data in the univariate analysis, the group comparison showed a significantly higher rate of patients admitted to hospital under CPR among VL group patients [447/2201 (20.3%) versus 1679/12,186 (13.7%); $p < 0.001$]. The rate of 30-day survival/hospital discharge was significantly higher in the VL group [335/2201 (15.2%) versus 1571/12,186 (12.9%); $p = 0.003$]. In addition, the analysis for the neurological outcome revealed a significantly higher rate of hospital discharge with CPC1/2 status among VL group patients [227/2201 (10.3%) versus 987/12,186 (8.1%); $p < 0.001$]. Primary ROSC rate and hospital admission with ROSC rate showed no significant difference between the two groups (Table 1).

Multivariate regression

The multivariate logistic regression model applied for the primary endpoint of CPC1/2 revealed that use of VL was an independent predictor of CPC1/2 survival (OR = 1.34, 95% CI = 1.12–1.60). The model achieves a value of 0.37 according to Nagelkerke's R squared. Further independent predictors in this model were witnessed cardiac arrest by bystander (OR = 1.73, 95% CI = 1.47–2.

Table 1 – Group comparison of video laryngoscopy (VL) versus direct laryngoscopy (DL): Univariate analysis of patient characteristics and outcome.

	Group VL (*n* = 2201)	Group DL (*n* = 12,186)	x^2 or *t*-test *p* value	Odds ratio (95% CI)
Group comparison: patient characteristics				
Mean age [mean ± SD]	68.94 (±15.04)	69.85 (±14.82)	**0.008**	
Proportion aged > 80 years [*n*, %]	611 (27.8)	3561 (29.2)	0.164	0.93 (0.84–1.03)
Male [*n*, %]	1480 (67.2)	8151 (66.9)	0.745	1.02 (0.92–1.12)
PES categories 1–5 and unknown [mean ± SD]:	52.54 (±29.04)	52.96 (±28.48)	0.534	
Location of CA: public or physician's office [*n*, %]	460 (20.9)	2559 (21.0)	0.916	0.99 (0.89–1.11)
Location of CA: home [*n*, %]	1442 (65.5)	7834 (64.3)	0.268	1.06 (0.96–1.16)
Location of CA: nursing home [*n*, %]	194 (8.8)	1108 (9.1)	0.675	0.97 (0.82–1.13)
Bystander witnessed CA [*n*, %]	1045 (47.5)	5631 (46.2)	0.272	1.05 (0.96–1.15)
Bystander EMS witnessed CA [n, %]	191 (8.7)	1021 (8.38)	0.642	1.04 (0.88–1.22)
Bystander CPR [*n*, %]	928 (42.2)	5111 (41.9)	0.847	1.01 (0.92–1.11)
Mean duration alarm EMS to chest compressions [h:min:s av, ± SD]	00:07:16 (±00:07:17)	00:07:23 (±00:07:09)	0.521	
Use of any mechanical resuscitation device [*n*, %]	434 (19.7)	1559 (12.8)	**< 0.001**	1.67 (1.49–1.88)
First rhythm VF/VT [*n*, %]	578 (26.3)	3053 (25.1)	0.230	1.07 (0.96–1.18)
First rhythm asystole/PEA [*n*, %]	1623 (73.7)	9081 (74.5)	0.440	0.96 (0.87–1.06)
First rhythm asystole [*n*, %]	1007 (45.8)	6106 (50.1)	**< 0.001**	0.84 (0.77–0.92)
Intravenous access [*n*, %]	2074 (94.2)	11,332 (93.0)	**0.03**	1.23 (1.02–1.49)
Intraosseous access [*n*, %]	713 (32.4)	2323 (19.1)	**< 0.001**	2.03 (1.84–2.25)
Adrenaline [*n*, %]	1976 (89.8)	10,492 (86.1)	**< 0.001**	1.42 (1.22–1.64)
Mean duration alarm EMS to ETI [h:min:s av. ± SD]	00:19:33 (±00:11:37)	00:19:41 (±00:12:28)	0.703	
ETI by emergency physician [*n*, %]	2188 (99.4)	11,920 (97.8)	**< 0.001**	3.76 (2.15–6.57)
Airway management complications [*n*, %]:				
1) Unknown, not reported	1785 (81.1)	11,034 (90.5)	**< 0.001**	0.45 (0.40–0.51)
2) Multiple attempts at ETI	408 (18.5)	1139 (9.3)	**< 0.001**	2.21 (1.95–2.50)
3) Cricothyrotomy	8 (0.4)	13 (0.1)	**0.006**	3.42 (1.41–8.25)
Assumed origin of CA or unknown [*n*, %]	1655 (75.2)	9471 (77.7)	**0.009**	0.87 (0.78–0.97)
Hypoxic cause of CA [*n*, %]	381 (17.3)	1,868 (15.3)	**0.02**	1.16 (1.02–1.30)
Near-drowning cause of CA [*n*, %]	11 (0.5)	46 (0.4)	0.401	1.33 (0.69–2.56)
Mean duration of EMS mission [h:min:s av. ± SD]	01:06:31 (±00:20:01)	01:05:33 (±00:20:17)	0.126	
Group comparison: outcome data				
ROSC rate [*n*, %]	1153 (52.4)	6311 (51.8)	0.606	1.02 (0.94–1.12)
Hospital admission with CPR [*n*, %]	447 (20.3)	1679 (13.7)	**< 0.001**	1.59 (1.42–1.79)
Hospital admission with ROSC [*n*, %]	906 (41.2)	5127 (42.1)	0.426	0.96 (0.88–1.06)
Hospital admission, incomplete data [*n*, %]	103 (4.7)	1042 (8.6)	**< 0.001**	0.53 (0.43–0.65)
30-Day survival or hospital discharge [*n*, %]	335 (15.2)	1571 (12.9)	**0.003**	1.21 (1.07–1.38)
Hospital discharge rate [*n*, %]	316 (14.4)	1533 (12.6)	**0.02**	1.16 (1.02–1.33)
Hospital discharge with CPC1/2 [*n*, %]	227 (10.3)	987 (8.1)	**< 0.001**	1.30 (1.12–1.52)
Hospital discharge with CPC3/4 [*n*, %]	38 (1.7)	204 (1.7)	0.860	1.03 (0.73–1.46)
Missing CPC status [*n*, %]	51 (2.3)	342 (2.8)	0.195	0.82 (0.61–1.11)

* CA – Cardiac arrest, CPC – cerebral performance category, EMS – Emergency medical service, ETI – endotracheal intubation, CPR – cardiopulmonary resuscitation, PEA – Pulseless electrical activity, PES – Pre-emergency status, ROSC – return of spontaneous circulation, VF – ventricular fibrillation, VT – ventricular tachycardia.

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05), by EMS team (OR = 2.66, 95% CI = 2.07–3.42) or in public (OR = 1.41, 95% CI = 1.19–1.66), at working place, school, sports (OR = 1.69, 95% CI = 1.29–2.21) and in the physician's office (OR = 1.61, 95% CI = 1.07–2.42). A negative correlation could be demonstrated for increasing patient age, poorer PES, increasing dose of adrenaline and asystole or PEA as primary rhythm and arrest in a nursing home. Bystander CPR and presumed aetiology (hypoxic/cardiac) were no independent predictors of CPC1/2 survival in our cohort (Fig. 2).

When applying the multivariate logistic regression model for the secondary endpoint of hospital discharge/30-day survival, the use of VL again was an independent predictor (OR = 1.26, 95% CI = 1.08–1.47). The model achieves a value of 0.39 according to Nagelkerke's R squared. Further independent positive predictors were witnessed cardiac arrest by bystander, by EMS team and location of cardiac arrest in public, at working place, school, sports, physician's office and suspicion of hypoxic cardiac arrest. A negative correlation could be demonstrated for increasing patient age, poorer PES, increasing dose of adrenaline, cardiac arrest in a nursing home and asystole or PEA as primary rhythm (Fig. 3).

Discussion

Our data consistently demonstrate a significant association between VL and neurologically good survival (CPC1/2) in a large cohort of prehospital resuscitations.

Hospital discharge/30-day-survival rate was significantly higher in VL patients, whereas primary ROSC rate did not differ significantly between groups.

We assume that this association is presumably due to early sufficient oxygenation lowering the rate of neurological damage. A lower rate of hypoxemia under VL could be demonstrated in a recent meta-analyses.[22]

Patients in the VL group had a significantly higher rate of difficult airway management complications (18.5% of cases versus 9.3%; $p < 0.001$), which may reflect the use of VL as a rescue option in difficult airway management and failed DL attempts. The higher rate of difficult airway management complications in the VL group may also be the reason for the higher rate of physician-performed intubations, because trained paramedics occasionally perform intubations with uncomplicated airways. However, the rate of non-physician intuba-

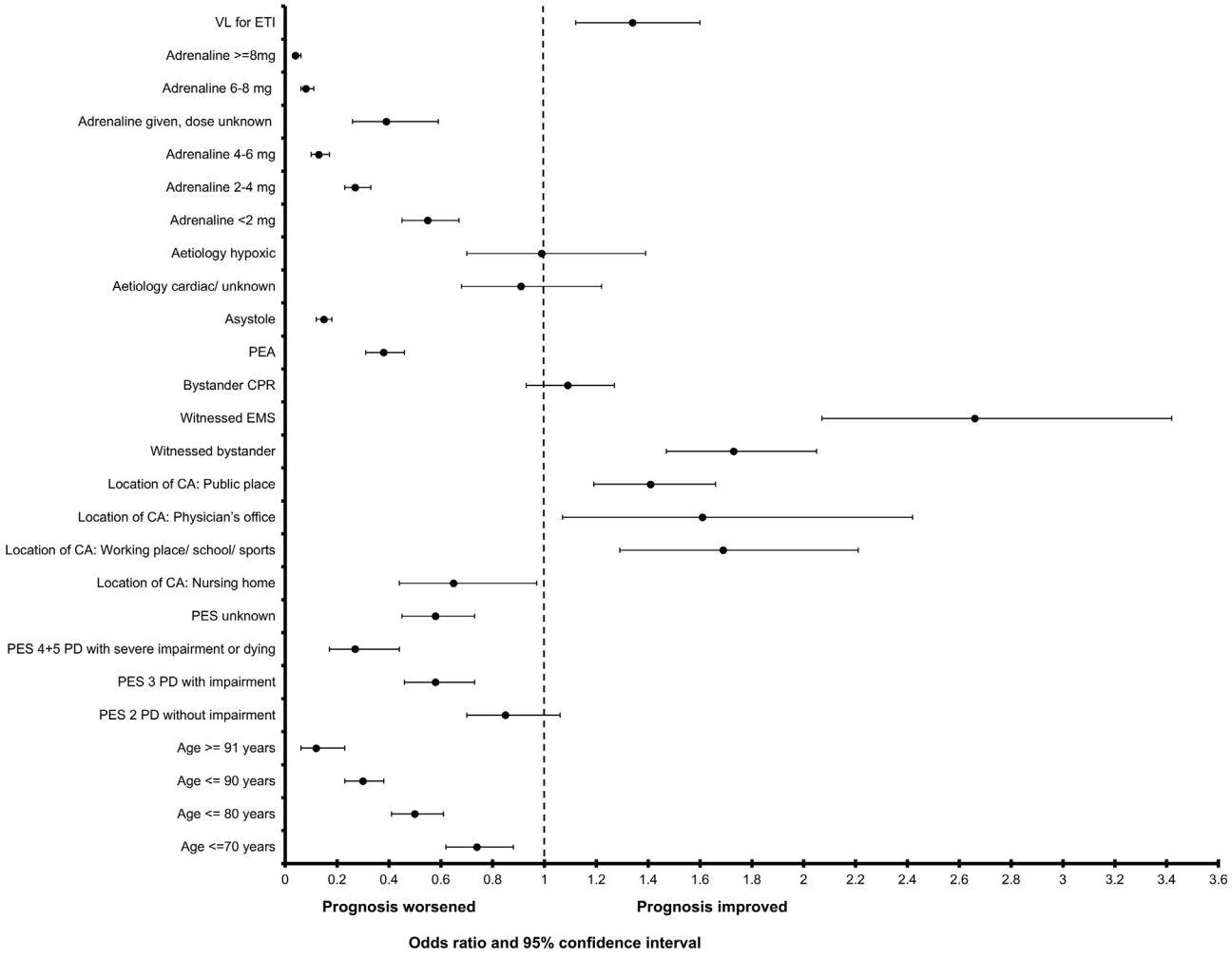

Fig. 2 – Results of multivariate logistic regression analysis for the primary endpoint of discharge with cerebral performance categories one and two (CPC1/2).

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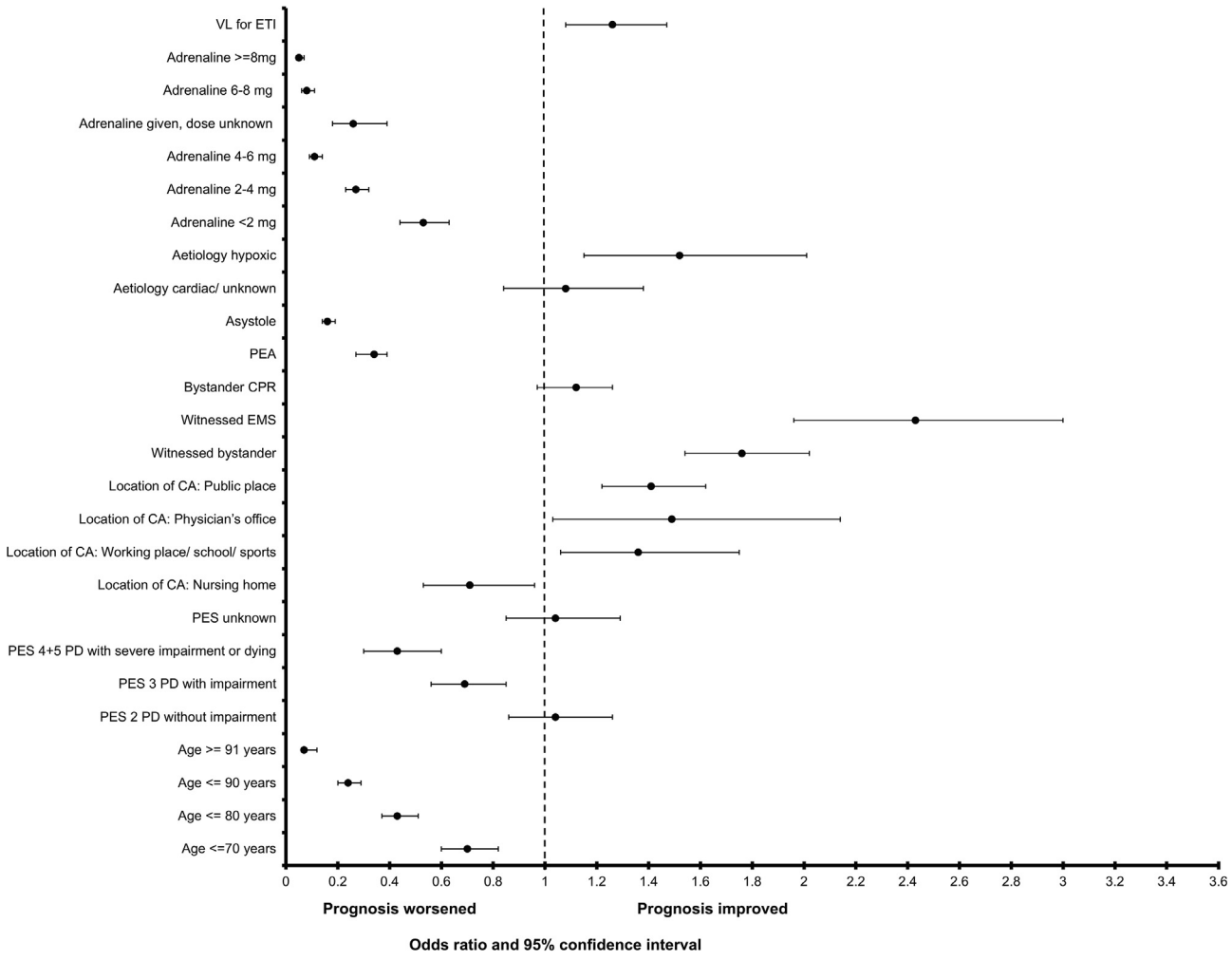

Fig. 3 – Results of multivariate logistic regression analysis for the secondary endpoint of discharge or 30-day survival.

tions in both groups is generally very low, at 0.6% and 2.2%, respectively.

Although the data were generated on the background of a physician-staffed EMS system, they should also be of interest to other systems: since VL is easy to teach, has a steep learning curve and involves intuitive handling, it could be beneficial for paramedic EMS systems as well. The primacy of VL at OHCA is also underlined by two recently published studies from paramedic systems that examined the advantages of VL in patients with OHCA when used by paramedics in suspected or confirmed COVID-19 intubation scenarios.[23–24]

Given a VL utilisation rate of only 10–12% in the study period from 2018–2021, the present data suggest its use as the first choice in prehospital airway management. The widespread use of VL is strongly encouraged and is likely to be associated with an increase in neurologically good survival rates.

Limitations

This study shows the limitations of a retrospective registry analysis because it can show associations, but the causes of the effects often remain unknown. In addition, data entry errors and missing data cannot be completely ruled out. Missing data had been declared in the baseline table. Although the rate of incomplete outcome data was higher in the DL group, there was no significant difference for missing data concerning the primary endpoint CPC 1/2. During MV analysis, missing data were included in the categories likely to cause no significant positive bias in terms of primary outcome. Although we tried to consider known confounders in the multivariate model, this could be incomplete with the risk of further bias. Differentiating between confounders and mediators of the multivariate model is sometimes challenging in detail. We intentionally included adrenaline groups as a surrogate parameter for resuscitation duration as a confounder, but these could be mediators as well. Detailed information relevant to every specific case, such as the clinical basis of the treating teams' decisions, was not available and could have been crucial for the chosen strategy and specific course of events. In addition, local preferences in the use of VL or DL cannot be derived from the given GRR´s data set and may be a potential confounder.

Conclusions

Our study showed a positive association between VL and more favourable neurological outcome after OHCA. Further prospective studies are required to confirm the advantages of VL in airway management during OHCA. The use of VL as a first-line choice should be

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trained and encouraged, especially in physician-staffed systems such as the one discussed here and it may be beneficial in paramedic systems as well. The current use rate of approximately 12% offers a promising perspective for further prognostic improvements after OHCA.

Conflicts of Interest

None, the authors declared that they have no competing interests.

Ethical approval

Ethical approval was granted by the ethics committee of the University of Duisburg-Essen (Chairperson: Prof. Dr. U. Schara-Schmidt, Robert-Koch-Str. 9-11 | 45147 Essen, Germany, email: ethikkommission@uk-essen.de; file number 21-10080-BO; date of positive vote 21.05.2021). This study was performed in compliance with recognised international standards, including the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Funding

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Availability of data and material

The data that support the findings of this study are available from the GRR. The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

J.R., D.F. C.K. and M.F. analysed and interpreted the patient data; J. R., D.F., M.F. and C.K. wrote the manuscript; K.M.M., K.F.S. and R. M. helped to revise and edit the manuscript; and D.P. provided the conceptual design and revised the manuscript. All authors read and approved the final manuscript.

Authors' information

Our study adheres to the STROBE guidelines for reporting observational studies.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2023.109688.

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