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Clinical paper

One year experience with fast track algorithm in patients with refractory out-of-hospital cardiac arrest

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Abstract

Background: Overall prognosis in patients with out-of-hospital cardiac arrest (OHCA) remains poor, especially when return of spontaneous circulation (ROSC) cannot be achieved at the scene. It is unclear if rapid transport to the hospital with ongoing cardiopulmonary resuscitation (CPR) improves outcome in patients with refractory OHCA (rOHCA). The aim of this study was to evaluate the effect of a novel fast track algorithm (FTA) in patients with rOHCA.

Methods: This prospective single-center study analysed outcome in rOHCA patients treated with FTA. Historical patients before FTA-implementation served as controls. rOHCA was defined as: persistent shockable rhythm after three shocks and 300 mg of amiodarone or persistent non-shockable rhythm and continuous CPR for 10 min without ROSC after exclusion of treatable arrest causes.

Results: 110 consecutive patients with rOHCA (mean age 56 ± 14 years) were included. 40 patients (36%) were treated with FTA, 70 patients (64%) served as historical controls. Pre-hospital time was significantly shorter after FTA implementation (69 ± 18 vs. 79 ± 24 min, p = 0.02). Favourable neurological outcome (defined as cerebral performance categories Score 1 or 2) was significantly more frequent in FTA patients (27.5% vs. 11.4%, p = 0.038). FTA-implementation showed a trend towards improved mortality (70.0% vs. 82.9%, p = 0.151). Extracorporeal Life Support was similar between the two groups.

Conclusion: Our study suggests that a rapid transport algorithm with ongoing CPR is feasible, improves neurological outcome and may improve survival in carefully selected patients with rOHCA.

Keywords: Refractory cardiac arrest, Extracorporeal cardiopulmonary resuscitation, Ongoing CPR, Out-of-hospital cardiac arrest, Neurological outcome

Abbreviations: AMI, acute myocardial infarction; BLS, basic life support; CA, cardiac arrest; CPC, cerebral performance categories; CPR, cardiopulmonary resuscitation; ECLS, Extracorporeal Life Support System; eCPR, extracorporeal cardiopulmonary resuscitation; EMS, emergency medical service; EP, emergency-physician; FTA, fast track algorithm; OHCA, out of-hospital cardiac arrest; PCI, percutaneous coronary intervention; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation.

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Introduction

Despite all efforts, mortality in patients with out-of-hospital cardiac arrest (OHCA) has remained almost unchanged at >90% for the last decades.[1] Cardiac etiology is presumed to be the most common cause of OHCA,[2,3] with acute myocardial infarction (AMI) seen in 35% to 80% of patients.[4–7] Percutaneous coronary intervention (PCI) has been demonstrated to improve outcome in OHCA patients.[8,9] However, patients in which ROSC cannot be established often do not reach the hospital and die at the scene. It is currently the subject of discussion whether transport to the hospital with ongoing cardiopulmonary resuscitation (CPR) improves survival and neurological outcome in patients with refractory OHCA (rOHCA).[10] Current resuscitation guidelines recommend considering transport with ongoing CPR if an immediate access to a catheterization laboratory is available with teams experienced in mechanical and/or haemodynamic support and rescue PCI with ongoing CPR.[11] However, precise criteria for patient selection are lacking and the optimal time point for transportation is still unclear. On the other hand, there is growing evidence that carefully selected patients[12–15] can benefit from an early transport to the hospital with ongoing CPR for further treatment.[16–18] The hypothesis of the study was that a structured algorithm for rapid pre-hospital management by the emergency medical service (EMS) improves outcome in rOHCA patients.

Patients and methods

The EMS in Cologne is run by the Fire Department of Cologne and supported by partnering aid organizations. They cover an area of approximately 405 km^2, servicing a population of more than 1 million. In case of resuscitation, telephone CPR is initiated by an EMS dispatcher. As a physician-based system, both an emergency-physician (EP) and a paramedic team are called to every OHCA.

In this single-centre observational study, outcome of patients with rOHCA treated with FTA and feasibility of the FTA itself were prospectively analysed and compared to patients of a historical control group (Fig. 1). Refractory OHCA was defined as cardiac arrest (CA) unresponsive to three shocks and 300 mg of intravenous/intraosseous amiodarone without achieving ROSC. In case of witnessed non-shockable rhythm, rOHCA was defined as persistent arrest after exclusion of treatable CA causes and continuous CPR for 10 min. ROSC was defined as the presence of a palpable pulse for a period of ≥20 s.[19,20] No-flow time was only assessed in witnessed cardiac arrest patients. In the remaining cases the exact no flow time has remained unclear. Time to ROSC was calculated from the time of collapse to ROSC. Pre-hospital time was calculated from the time of collapse until hospital admission.

All patients in the study received standard resuscitation treatment according to current recommendations,[11,21,22] including endotracheal airway management and intravenous/intraosseous catheterization. Out-of-hospital ultrasound (VScan®, GE Healthcare, Solingen, Germany) was available to identify treatable OHCA causes. Patients with ongoing CPR were transported with an automated CPR device (Lund University Cardiac Arrest-2 System; Physio-Control Inc., Redmond, Washington).

The investigation was approved by the Ethics Committee of the University of Cologne and conforms to the principles outlined in the Declaration of Helsinki (Reference number 17–071). Only routinely collected clinical data were used in this study.

Fast track algorithm

The FTA was established by the department of emergency medicine of the Cologne fire department in cooperation with the Department of Cardiology of the University Hospital of Cologne and in line with current resuscitation guidelines.[11,21,22] Selection criteria (Table 1) were defined based on patients with a high potential treatment benefit from ongoing CPR, early PCI and Extracorporeal Life Support System (ECLS). Patients <18 years of age, pregnant patients and patients with traumatic arrest were excluded from the study. Patients with rOHCA who were transferred from another hospital to our department were excluded as well. FTA patients were enrolled at the University Hospital of Cologne between January and December 2018. The University Hospital of Cologne has 24/7 PCI and eCPR availability and experienced personal in rescue PCI with ongoing CPR.

The implementation of FTA had several objectives: (i) selection of suitable patients who would benefit most from transport to hospital with ongoing CPR for further therapy such as PCI and ECLS, (ii) reduction of pre-hospital time with a target time <60 min, (iii) direct transfer of all rOHCA patients to the catheterization laboratory and (iv) improving outcome in rOHCA patients. To achieve these aims, a structured pre-hospital approach was implemented and the EMS staff were informed about the novel algorithm. Out-of-hospital ultrasound was performed by EP as soon as possible to identify and treat reversible causes of CA when indicated. Patients with rOHCA were immediately evaluated for FTA in accordance with the criteria mentioned above. Patients who met all selection criteria were transported to the eCPR hospital with ongoing CPR as fast as possible after direct communication between EP and intensive care specialist. Otherwise, resuscitation was continued at the scene until ROSC or termination of the treatment. Individual transport decisions in patients who did not meet all FTA criteria were nevertheless possible according to the discretion of the EP on scene. Also, in case of ROSC, patients could be transported to the next hospital with PCI availability. These patients were then excluded from the study. The detailed algorithm is presented in Fig. 2a.

Historical protocol

Patients of the historical group had been enrolled in a preliminary study of the same authors between January 2014 and December 2017.[13] Before FTA implementation, decisions on patient selection, transport with ongoing CPR and time point were individually taken by the EP at the scene in accordance with the current resuscitation Guidelines.[11,21] Target hospital was not predetermined and patients with AMI as suspected cause of OHCA were transported directly to the catheterization laboratory of one of seven hospitals with continuous PCI availability. Of note, only one of the seven hospitals had eCPR availability and only patients transported to the eCPR hospital were included into the control group.

Hospital treatment protocol

All patients were treated equally by an interdisciplinary team comprising an interventional cardiologist, an intensive care specialist and a cardiac surgeon. After structured handover and general clinical examination, ultrasound and arterial blood gas analysis were performed to identify treatable causes of cardiac arrest (CA) (Fig. 2b). If patients could not be stabilized using conservative measures, they were evaluated for eCPR in accordance with current recommendations (Supplement Table S2).[23] In addition, Impella microaxial pump (Abiomed, Danvers, Massachusetts) was implanted, if needed. The diagnosis of AMI as the underlying cause of

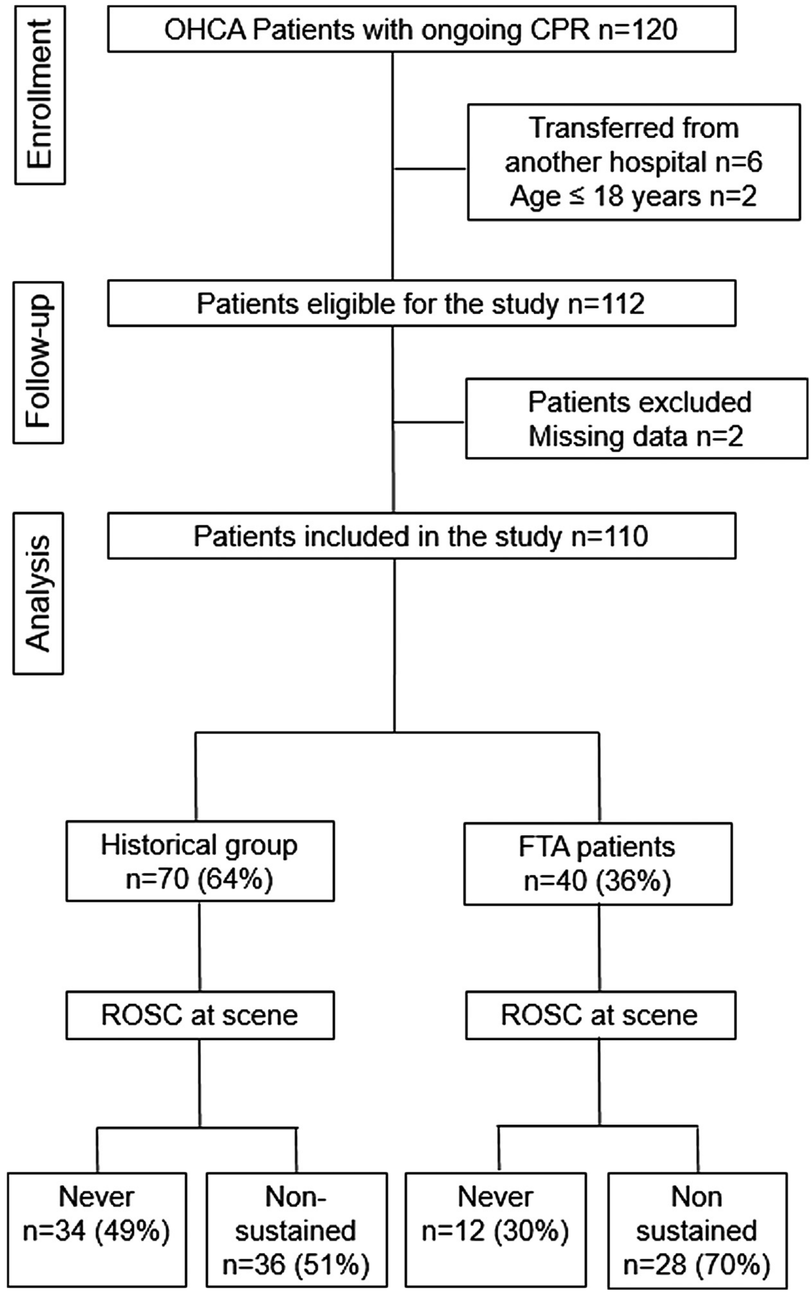

Fig. 1 – Patient disposition.
OHCA, out-of-hospital cardiac arrest; CPR, cardiopulmonary resuscitation; FTA, fast track algorithm; ROSC, return of spontaneous circulation.

rOHCA was adjudicated by an experienced interventional cardiologist based on coronary angiography with either acute coronary vessel occlusion or presence of a potential culprit lesion. In case of stabilisation, coronary angiography and revascularization was performed when indicated. Patients without AMI underwent further diagnostic evaluation with cranial, chest and/or abdominal computed tomography applied for identification of other potential causes of CA. Patients were treated with target temperature management (32–36 °C) for 24 h according to our routine institutional protocol. If patients could not be stabilised, the final cause of CA could not be determined.

Study endpoint

The main objectives were the evaluation of feasibility and efficacy of FTA in patients with rOHCA. The rate of patients treated according to FTA was assessed. Prehospital time was evaluated as mentioned above. Neurological outcome was registered in all patients at hospital discharge based on the Glasgow–Pittsburgh cerebral performance categories (CPC) of the Utstein recommendations.[24] For analyses, neurologic outcome was dichotomized into favourable (CPC 1–2) and poor (CPC 3–5).

Table 1 – Fast track algorithm (FTA) Selection criteria.

Inclusion criteria
- Age 18–75 years
- Witnessed cardiac arrest
- No flow time ≤5 min
- Effective bystander-CPR
- Initially shockable rhythm or a non-shockable rhythm in combination with witnessed cardiac arrest due to the EMS staff
- Cardiac event as the suspected cause of arrest

Exclusion criteria
- Known terminal illness
- Do not resuscitate status
- Impossible use of automated CPR device due to anatomical conditions

EMS, emergency medical service; CPR, cardiopulmonary resuscitation.

Statistical analysis

Empirical distributions of qualitative (categorical) variables were summarized as absolute numbers and percentages, those of quantitative variables as mean ± standard deviation (SD) Categorical variables and continuous variables were compared between groups by the Fisher's exact test and the Student t-test, respectively. Statistical calculations were performed using SPSS Statistics 25 (IBM Corp., Armonk, NY, USA) and R 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). A p value <0.05 was considered statistically significant.

Results

Baseline characteristics and pre-hospital time

One hundred and twenty consecutive patients with rOHCA were admitted to the Department of Cardiology during the study period. Ten patients were excluded from the analysis for various reasons (Fig. 1). One hundred and ten patients with a mean age of 56 ± 14 years were included into the study. Of the 110 study subjects, 70 (64%) reached the hospital before and 40 patients (36%) after FTA implementation. Nearly 60% of the all patients presented with definite cardiac cause of OHCA. AMI was the most common cause of OHCA (42%) followed by primary arrhythmia (14%) and myocarditis (2%). There were no differences between the two groups in age, gender or cause of OHCA (Table 2). Twenty-one FTA patients (53%) fulfilled all pre-defined selection criteria. The remaining patients were transported due to individual transport decision taken by the EP at the scene. In contrast, only 22 patients (31%) of the historical group fulfilled the selection criteria ($p = 0.04$).

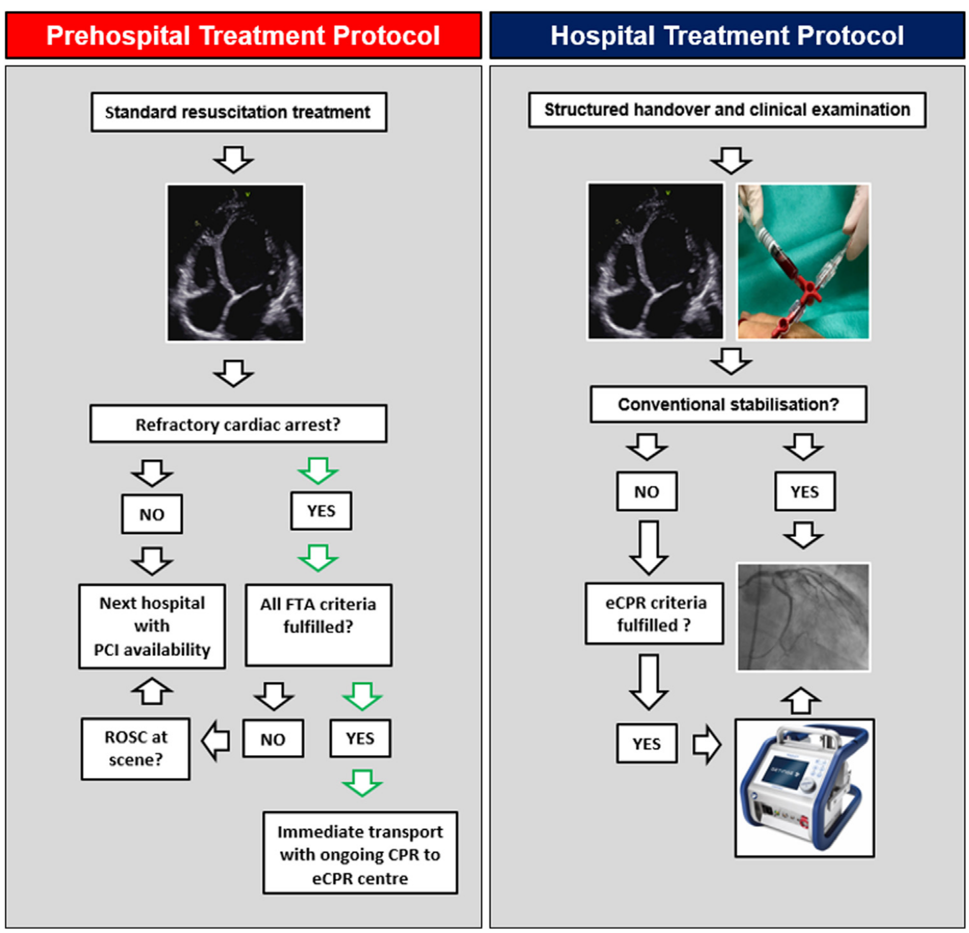

Fig. 2 – (a) Prehospital treatment (left side) protocol after FTA implementation and (b) hospital treatment protocol of rOHCA patients (right side).
ROSC, return of spontaneous circulation; eCPR, extracorporeal cardiopulmonary resuscitation; PCI, percutaneous coronary intervention.

Pre-hospital time was significantly shorter after FTA implementation. FTA patients reached the hospital after 69 ± 18 min. In contrast, patients of the historical group needed 79 ± 24 min on average (p = 0.02). After FTA implementation, 88% of patients were transferred directly to the catheterization laboratory, in contrast to 69% of historical patients (p = 0.06). In 6% of patients treatable causes of CA were successfully diagnosed using out-of-hospital ultrasound. Five patients with acute right ventricular enlargement received systemic thrombolytic therapy at the scene and pericardiocentesis was performed in one patient with pericardial tamponade. All of these patients presented with pulseless electrical activity (PEA). Sixty-four patients (58%) achieved a non-sustained ROSC at the scene with a trend towards higher occurrence in FTA patients (70% vs. 51%, p = 0.071) (Fig. 1). However, continuous stabilization was not achieved and all patients suffered rearrest and were transported to the hospital with ongoing CPR.

Hospital treatment

As shown in Table 2, there were no significant differences regarding the frequency of PCI (35% vs. 46%, p = 0.3) and eCPR (25% vs. 21%, p = 0.81) between the two groups, whereas the combined therapy with eCPR and microaxial pump (ECMELLA) was more frequent in FTA patients (13% vs. 1%, p = 0.02). After admission, successful stabilisation under conservative treatment was achieved in 13 FTA patients (33%) and in 21 patients of the historical group (30%) (p = 0.83).

Mortality and neurological outcome

Overall hospital mortality was 78%. After FTA implementation, there was a tendency towards decrease in mortality, although it did not reach statistical significance (FTA group: 70% vs. historical group: 83%; p = 0.151) (Fig. 3). A favourable neurological outcome was

Table 2 – Clinical characteristics of included patients.

Characteristic	Study population (n = 110)	Historical group (n = 70)	FTA group (n = 40)	P value
Age (years)	56 ± 14	55 ± 15	59 ± 13	0.16
Female – n (%)	18 (16)	12 (17)	6 (15)	1.00
Cause of cardiac arrest				
Myocardial infarction – n (%)	46 (41.8)	32 (45.7)	14 (35)	0.32
Primary arrhythmia – n (%)	15 (13.6)	7 (10)	8 (20)	0.16
Pulmonary embolism – n (%)	5 (4.5)	4 (5.7)	1 (2.5)	0.65
Myocarditis – n (%)	2 (1.8)	0 (0)	2 (5)	0.13
Asphyxia – n (%)	3 (2.7)	2 (2.9)	1 (2.5)	1.00
Aortic dissection – n (%)	2 (1.8)	1 (1.4)	1 (2.5)	1.00
Unclear cause – n (%)	37 (33.6)	24 (34.3)	13 (32.5)	1.00
Cardiac arrest characteristics				
Witnessed arrest – n (%)	67 (60.9)	43 (61.4)	24 (60)	1.00
No-flow-time (min)	2.5 ± 2.9	2.7 ± 3.3	2.2 ± 2.4	0.46
BLS provided by bystander – n (%)	56 (50.9)	32 (45.7)	24 (60)	0.16
Shockable rhythm – n (%)	77 (70)	49 (70)	28 (70)	1.00
Number of shocks	5.6 ± 4.6	5.5 ± 4.7	5.8 ± 4.8	0.73
Dose of epinephrine during CPR (mg)	10.1 ± 6.4	10.2 ± 7.0	10.2 ± 5.2	0.86
Non-sustained ROSC – n (%)	64 (58)	36 (51)	28 (70)	0.07
Time to ROSC (min)	40 ± 33	43 ± 39	34 ± 20	0.26
Prehospital time (min)	76 ± 23	79 ± 24	69 ± 18	0.02
Mechanical assist devices				
ECLS – n (%)	25 (22.7)	15 (21.4)	10 (25)	0.81
Impella microaxial pump – n (%)	7 (6.4)	2 (2.9)	5 (12.5)	0.09
ECMELLA – n (%)	6 (5.5)	1 (1.4)	5 (12.5)	0.02
Catheterization laboratory				
Coronary angiography – n (%)	57 (51.8)	36 (51.4)	21 (52.5)	1.00
PCI – n (%)	46 (41.8)	32 (45.7)	14 (35)	0.32
Initial blood gas analysis				
Serum lactate (mmol L − 1)	14.6 ± 5.0	14.0 ± 5.1	15.4 ± 4.9	0.20
Arterial pH	6.9 ± 0.6	6.9 ± 0.2	6.9 ± 0.2	0.11

BLS, basic life support; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation; ECLS, Extracorporeal Life Support System; PCI, percutaneous coronary intervention; ECMELLA: Combined microaxial pump and ECLS therapy.

significantly more frequent in the FTA group compared to patients of the historical group (28% vs. 11%; p = 0.038) (Fig. 4).

Of all patients that achieved a non-sustained ROSC at the scene, 19 (30%) were discharged alive from hospital. In contrast, in 46 patients (42%) it was not possible to reach ROSC at the scene and only five of these patients (11%) survived the event (p = 0.03).

Subanalysis of fast track algorithm patients

We performed a subanalysis of strict per-protocol FTA patients, excluding FTA patients who had undergone rapid transport according to the discretion of the EP without meeting all FTA selection criteria (Supplement Table 1). Outcome analysis of per-protocol FTA patients revealed a significantly improved neurological outcome (52% vs. 0%; $p < 0.01$) and more importantly, a significantly reduced hospital mortality (48% vs. 95%; $p < 0.01$) compared to patients with individual transport decision.

Discussion

In this study, we investigated the feasibility and efficacy of a modified resuscitation algorithm on outcome in patients with rOHCA. The main finding was a significant decrease in pre-hospital treatment time as well as an increase in proportion of patients with favourable neurologic outcome after FTA implementation compared to the historical control group.

The pre-hospital selection of patients who could benefit from transport with ongoing CPR plays a key role and strongly influenced the results of further treatment. Our group was able to demonstrate, that factors such as witnessed arrest, an initial shockable rhythm and cardiac cause of OHCA could reliably predict good neurological outcome in patients with rOHCA.[13] These findings are in line with previous reports which showed that a witnessed CA[6,25], bystander CPR,[26] short low-flow duration[6,15] and an initial shockable rhythm[6,7,15,27] were associated with better outcomes in OHCA patients and have thus been chosen as selection criteria for the FTA. In contrast to other protocols that had included only patients with initial shockable rhythm,[12,14] we also included patients with non-shockable rhythm into the study. Furthermore, the physician-based EMS enabled the possibility of advanced treatment at the scene. The guidelines for resuscitation underline the importance of early detection and consistent treatment of potentially reversible CA causes.[21] In our investigation, almost 6% of patients presented with a treatable cause of CA diagnosed using ultrasound at the scene and all of these patients showed an initial PEA.

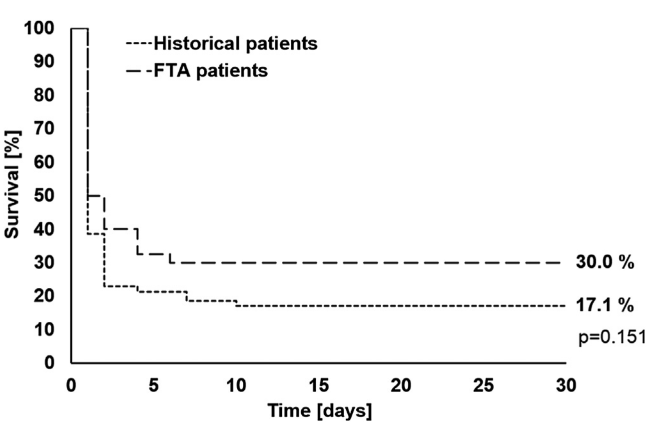

Fig. 3 – Thirty-day survival of included patients.

More than half of the analysed patients achieved a non-sustained ROSC at the scene. These patients showed a significantly better outcome compared to patients without pre-clinical ROSC. This finding is in line with previous investigations.[28] However, it should not be overlooked that five of our patients without ROSC at the scene were successfully stabilised in the hospital and survived the event.

After FTA implementation, we found a significant increase in proportion of patients with favourable neurologic outcome but only a tendency towards decrease in mortality. This difference might be explained by the fact that most patients with rOHCA and subsequent eCPR die within the first 24 h, typically from complications surrounding the initial event. A neuroprotective effect will not show this early but rather over the course of the long stay in the hospital. At the same time, we do see a trend towards an improved overall survival but the effect might have been too weak to show up the rather small group. Importantly, our subanalysis revealed that the mortality was significantly reduced in per-protocol FTA treated rOHCA patients, indicating that the effect might be underestimated in the complete FTA group.

Several reasons might account for the positive effects of FTA: First and most importantly, the FTA selection criteria include established positive variables for resuscitated patients, such as witnessed CA and effective bystander CPR. Also, we found a strong trend towards more patients that had been transported directly into the catheterization laboratory in the FTA group. As mentioned before, OHCA patients benefit from direct PCI regardless whether an AMI has been proven at the scene.[8,9] Finally, pre-hospital time was significantly shortened in the FTA group and this effect has likely influenced individual outcome of rOHCA patients as well. There is growing evidence that time management plays a central component in patients with OHCA. The authors of the FITSTEMI trial successfully demonstrated that the contact-to-balloon time $\leq$90 min was a significant and independent predictor for better survival in 1200 patients resuscitated due to ST-segment elevation myocardial infarction. In addition, every 10-min treatment delay resulted in a significant increase in mortality.[30] Wengenmayer et al. analysed the outcomes of 133 patients treated with eCPR following CA. Patients who survived the hospital stay had shorter low-flow duration than non-survivors (41.7 ± 15.0 vs. 62.6 ± 5.1 min, p = 0.003).[31] Similarly, Kuroki and co-workers were able to show that a shorter interval from collapse to commencement of eCPR (<40 min) as well as a shorter time from collapse to coronary reperfusion (<60 min) predicted better clinical outcome in patients with CA undergoing eCPR.[17] In daily pre-hospital practice, the rapid treatment and mobilisation of patients with rOHCA represents a challenge.[32] This is aggravated by the fact that the implementation of FTA requires a paradigm shift for the physician based EMS. Up to now, patients with OHCA were treated at the scene until ROSC or termination of the treatment.

Another relevant finding of our study was that one third of rOHCA patients could be stabilised successfully by conservative measures in the hospital. Similar results were recently demonstrated by a Danish group, who had analysed the outcome of 108 patients with rOHCA receiving conservative treatment

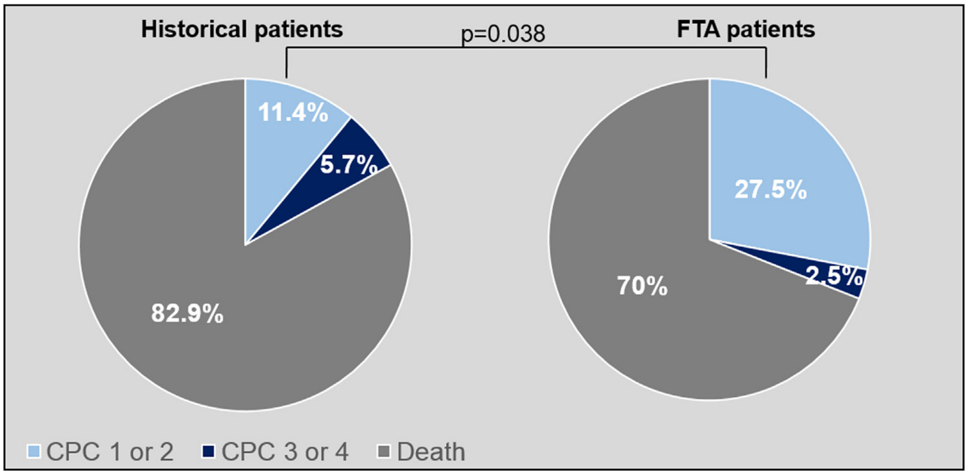

Fig. 4 – Neurological outcome at hospital discharge of historical patients (left side) and FTA patients (right side). FTA, fast track algorithm; CPC, cerebral performance categories.

without the use of eCPR. In this study, 52% of patients achieved ROSC in hospital when treated by a resuscitation team.[33] On the other hand, in nearly 23% of our patients a conservative stabilisation was unsuccessful and these patients needed additional mechanical support. Yannopoulos et al. analysed prospective data on patients with refractory arrest treated with a protocol of early transport to hospital for further therapy. 91% of these patients without sustained ROSC received eCPR. Accordingly, only 9% of the patients experienced ROSC before coronary angiography.[12] In contrast to our and the Danish study, 33 patients were treated at the scene by paramedics. A physician based EMS offers the opportunity for further treatment at the scene. This could partly explain the different rate of patients who could be stabilised using conservative treatment.

After FTA implementation, we observed an increase in patients who were transported to hospital with ongoing CPR. We speculate that the intensive team training and an increased routine in the practical implementation of the FTA leads to an exponential increase in recruited patients and then a doubling of incidence. On the other hand it is possible that some patients were transported to hospital who were previously not considered as rOHCA.

Our results underscore the relevance of implementation of CA-centres with experienced resuscitation teams and the possibility for advanced treatment for hemodynamic stabilisation. However, expertise and availability of eCPR is currently not established in most hospitals. Therefore, the treatment should be adapted to local conditions and a direct transfer to the next eCPR centre should be considered in carefully selected patients. Therefore, a close cooperation between hospitals and establishment of networks is necessary. In addition, standardised pre-hospital treatment algorithms are urgently needed for this high-risk patients.

Limitations

The present study has several limitations: (I) Our study was performed in cooperation with a high-performance EMS and a tertiary university hospital with a novel algorithm for treating patients with rOHCA. Therefore, it is not clear, whether our results are transferable to other EMS or hospital sectors. (II) The implementation of FTA resulted in bypassing of nearby clinics and we have not assessed individual time loss for each patient. As this potential bias would only affect the outcome of the FTA group, we believe that the central conclusion of our study will not be changed. Furthermore, the number and in particular the outcome of patients who were transported to another hospital is unclear. It must be assumed that patients with a poor prognosis were transferred away from the study hospital. Therefore, selection bias cannot be excluded. (III) Pre-hospital time was 69 min after FTA implementation. Thus, further practice of FTA procedure within the EMS is needed to reduce pre-hospital time and reach the target of 60 min in future. (IV) Another limitation may be the statistical method, as we do not use a matched pair approach. Due the single centre character and the fact that the two groups compared in the study were from different eras of enrolment, further prospective evaluation is warranted before routine recommendations regarding the suggested transport regimen in patients with rOHCA may be given.

Conclusion

Our study shows that the implementation of a novel modified resuscitation algorithm (into a physician-based EMS is feasible and significantly reduces pre-hospital time in rOHCA patients. Furthermore, FTA significantly improved neurological outcome and – if applied strictly in carefully selected individuals– overall survival in this otherwise doomed group of patients.

Conflict of interest

Bernd W. Böttiger is European Resuscitation Council (ERC) Board Director Science and Research; Chairman of the German Resuscitation Council (GRC); Member of the, Advanced Life Support (ALS) Task Force of the International Liaison Committee on Resuscitation

(ILCOR); Member of the executive committee of the German Interdisciplinary Association for Intensive and Emergency Medicine (DIVI); Associated Editor of the European Journal of Anaesthesiology (EJA), Co-Editor of “Resuscitation”; Editor of the Journal “Notfall + Rettungsmedizin”. He received professional fees for lectures from the following companies: Medupdate GmbH, “Forum für medizinische Fortbildung (FomF)”, Baxalta Deutschland GmbH, Bayer Vital GmbH, ZOLL Medical Deutschland GmbH, C. R. Bard GmbH, GS Elektromedizinische Geräte G. Stemple GmbH

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.07.035.

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