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Clinical Paper

The incidence of "load&go" out-of-hospital cardiac arrest candidates for emergency department utilization of emergency extracorporeal life support: A one-year review☆

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ABSTRACT

Background: The outcome of patients after out-of-hospital cardiac arrest (OHCA) is poor and gets worse after prolonged resuscitation. Recently introduced attempts like an early installed emergency extracorporeal life support (E-ECLS) in patients with persisting cardiac arrest at the emergency department (ED) are tried. The "Vienna Cardiac Arrest Registry" (VICAR) was introduced August 2013 to collect Utstein-style data. The aim of this observational study was to identify the incidence of patients which fulfil "load&go"-criteria for E-ECLS at the ED.

Methods: VICAR was retrospectively analyzed for following criteria: age <75 years; witnessed OHCA; basic life support; ventricular fibrillation/ventricular tachycardia; no return-of-spontaneous-circulation (ROSC) within 15 min of advanced-life-support, which were supposed as potential optimal criteria for "load&go" plus successful E-ECLS treatment at the ED. The observation period was from August 1, 2013 to July 31, 2014.

Results: Over 948 OHCA patients registered during the study period; data were exploitable for 864 patients. Of all patients, "load&go"-criteria were fulfilled by 55 (6%). However, 96 (11%) were transported with on-going CPR to the ED. Of these 96 patients, only 16 (17%) met the "load&go"-criteria. Similarly, among the 96 patients, 12 adults were treated with E-ECLS at the ED, with only 5 meeting the criteria. Among these 12 patients, favourable neurological outcome (CPC 1/2) was obtained in 1 patient without criteria.

Conclusion: Further promotion of these criteria within the ambulance crews is needed. May be these criteria could serve as a decision support for emergency physicians/paramedics, which patients to transport with on-going CPR to the ED for E-ECLS.

1. Introduction

Despite improvement in the quality of advanced life support (ALS), the outcome after out-of-hospital cardiac arrest (OHCA) still remains poor.[1] Nuernberger et al.[2] reported about the current survival and neurological outcome after OHCA in Vienna. Survival and favourable neurological outcome were determined through hospital-discharge (11.3%) and the cerebral performance category (CPC) of 1/2 (8.7%). There are several approaches aiming to improve neurologic outcome after resuscitation via strengthening the chain of survival; such as initiation of bystander-CPR and early defibrillation within the first link and mild hypothermia within one of the latter.[3] One promising approach, emergency extracorporeal life support (E-ECLS) for otherwise futile resuscitation efforts, even used outside the hospital, has shown some promising results.[4–7] Further studies are trying to investigate which patients should be transported with on-going cardiopulmonary

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resuscitation (CPR)[8–10] to the hospital. The aim of this observational study in particular was to identify which patients with persistent cardiac arrest might be candidates for a "load&go"-procedure for consecutive emergency department (ED) E-ECLS and their incidence within one year in Vienna. The "load&go" approach has its origin in traumatology. Seriously injured patients with multiple trauma or penetrating wounds can possibly be treated only inadequately at the scene and thus the time to hospital admission is decisive for the outcome of trauma patients.[11,12] In traumatology, the E-ECLS is applied as a supportive treatment till the definitive restoration is completed. This approach could be considered for the cardiac arrest as well. The E-ECLS, used as a supportive device till a definitive treatment, such as coronary angiography, can be performed. Recent evidence suggest that a better outcome could be achieved in patients which had a minimized duration until initiation E-ECLS.[8,13–15]

2. Methods

2.1. Study population

In July 2013, a register was introduced to record Utstein-style data of all OHCA in Vienna. The inclusion criteria were age >18 years and a resuscitation which was performed by the Municipal Ambulance Service of Vienna. The study-period was set from 7/2013 to 08/2014. The study protocol complies with the declaration of Helsinki and was approved by the local ethics committee of the Medical University of Vienna (EK 1221/2013).

2.2. "Load&go"-criteria

We considered five criteria as most important for "load&go" based on recent literature[8,16–18] and not excluding the possibility of a potentially reversible cause for cardiac arrest[10,16,19,20] as follows: an initially shockable rhythm, patient's age less than 75 years, a bystander witnessed collapse, bystander-CPR and no sustained return of spontaneous circulation (ROSC) within 15 min of ALS by emergency medical service (EMS).

2.3. Data acquisition

Patient data were collected by particularly trained chart reviewers and inserted into an in July 2013 introduced database, called the Vienna Cardiac Arrest Registry (VICAR). The demographic information, the defibrillator-data and specific data from the emergency run files of the Municipal Ambulance Service were recorded. These data were the patient's age, bystander CPR, witnessed collapse and the hospital patients were admitted to. The emergency medical system (EMS) in Vienna is executed by the Municipal Ambulance Service and supported by partner organizations. A system based on paramedics and emergency physicians is used. In case of resuscitation, paramedics and a separate emergency-physician are called to the scene. These paramedics are trained in ALS, including advanced airway-management and drug therapy. Additionally, police is dispatched as first responder to minimize 'no-flow'-time. After ROSC at the scene or the decision for transport with on-going CPR the patient will be taken to intramural care. Patients who were transported with on-going CPR arrived at 8 different hospitals. Of these, only three hospitals with a cardiac surgery department have the possibility to perform E-ECLS. All documented E-ECLS applications have been executed at the Vienna General Hospital.

According to the study protocol some patient records were not taken into account for final analysis due to the criteria being non-determinable. In respect to bystander-CPR and witnessed collapse, the chart-reviewers had to rely on clear notes in EMS treatment protocols. If these facts were not explicitly mentioned in the protocol, they were considered as absent. If there was no definite note in the protocol that at EMS-arrival a first responder CPR was performed, it was counted as absent. The initial rhythm was determined using the first derived rhythm after arrest. In cases where the initial rhythm was not clear because of artefacts, the patients were included but not counted as "load&go"-candidates. A shockable rhythm needed to be verifiable. Only when all data were clearly comprehensible and met all criteria, the patients were counted as "load&go"-candidates. The resuscitation duration was measured from first recognizable chest-compression on the data file extracted from defibrillators to either sustained ROSC or termination of the resuscitation efforts. Thus, it reflects only the time of ALS at the scene without bystander-CPR. Transport durations were measured from turning the defibrillator on to either switch off or removal of the defibrillation pads at the ED. There were cases where resuscitation was initiated before the defibrillator was used or the patient received CPR after initiation of monitoring via the defibrillator. Further, the moment of the removal of the defibrillator-pads or switching off the defibrillator was not specified. Thus, the patient could be already in the ED when the defibrillator was switched off. At the time of the investigation the "load&go"-protocol (Fig. 1) was not yet established for the EMS and the ED. The designated "load&go"-criteria have been used to evaluate the situation in the EMS and the ED retrospectively. There have been no mandatory criteria for ECLS application. Previous possible criteria were: accidental hypothermia, intoxication, a short duration to application and first observed blood parameters such as pH, lactate or potassium.

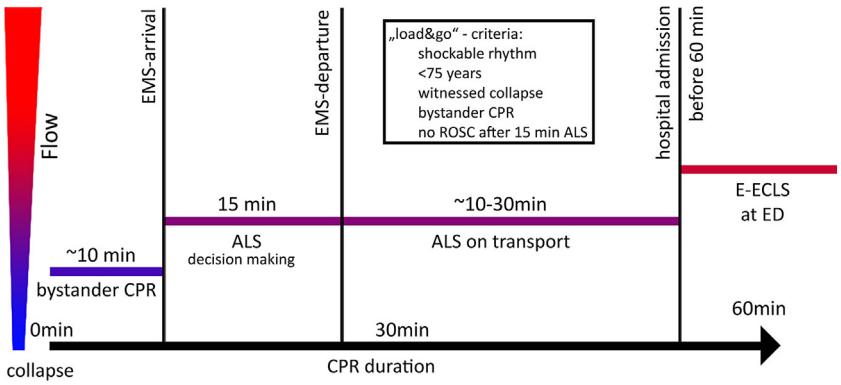

Fig. 1. Example for the clinical implementation of a "load&go"-protocol in patients who meet the criteria. EMS: emergency medical service; ALS: advanced life support; ROSC: return of spontaneous circulation; E-ECLE: emergency-extracorporeal life support; ED: emergency department.

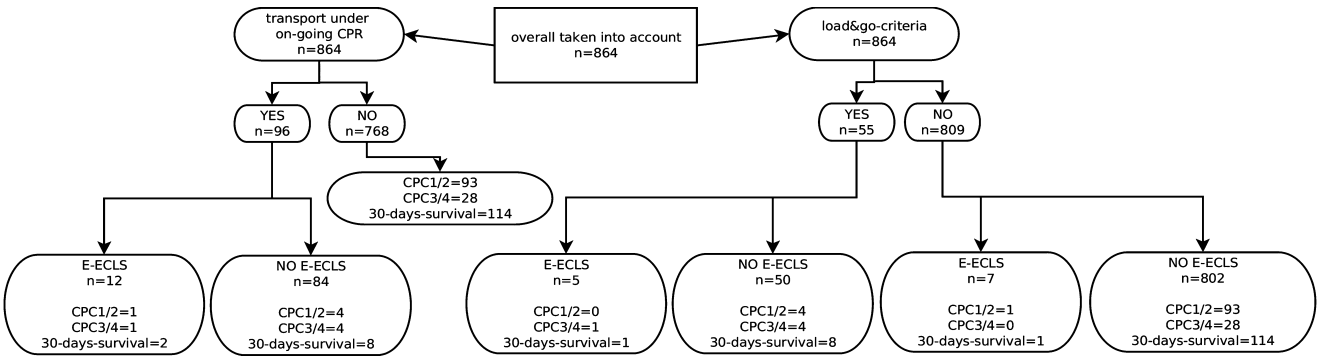

Fig. 2. Transport under on-going CPR, "load&go"-criteria. CPC: cerebral performance category; E-ECLS: emergency extracorporeal life support.

2.4. Endpoints

The endpoints of the study represent the number of patients who met all "load&go"-criteria and whether these were transported or treated at the scene. Further, the 30-day survival and favourable neurologic outcome (using the cerebral performance category (CPC) for good neurological performance 1 and moderate cerebral disability 2) were assessed, in comparison to whether the criteria were fulfilled or not and whether the patients were transported or remained at the scene. Mortality was determined via the termination of CPR at the scene or contacting the responsible physician at the hospital.

2.5. Statistical analysis

Continuous data are presented as median and interquartile-range (IQR) – discrete data as counts and percentages. Chi-square-test was used for comparison of categorical data and for comparison of continuous variables *t*-test was assessed. Statistical analyses were performed using PASW 22.0 (IBM SPSS, USA).

3. Results (Fig. 2)

The Vienna EMS treated 948 patients suffering cardiac arrest within the observation period. Because of missing data, not clearly determinable criteria or age <18 years, 84 patients had to be excluded. Thus, of 864 patients, transported with ongoing CPR were 96 (11%) and treated on site 768 (89%) patients; of the latter successfully ROSC was achieved in 257 (33.5%) cases and on scene died 511 (66.5%) patients (Table 1).

3.1. The distribution of criteria (Table 2)

Patients had to fulfil all above mentioned criteria to be eligible for the "load&go"-strategy. In 55 cases (6.4%) these were applicable. Of these patients, sustained ROSC at the scene after 15 min of ALS was achieved in 17 (2.0%) patients, transportation occurred in 16 (1.9%) patients and 22 (2.5%) patients were declared dead on scene.

3.2. Transported vs. treated on scene (Table 3)

All 864 patients were stratified into groups according to: transportation under on-going CPR ($n = 96$; 11%), CPR on the scene until termination of resuscitation efforts or achieving sustained ROSC ($n = 768$; 89%).

3.3. The 'transportation under on-going CPR' group

A total of 96 (11%) patients were transported with on-going CPR. The required "load&go" criteria were fulfilled in 16 (16.6%) cases. Of

Table 1
Baseline characteristics.

	Total	ROSC at the scene	Ongoing CPR on transport	Died on the scene	*p* value
Count (%)	864 (100)	257 (29.7)	96 (11.1)	511 (59.1)	
Gender, *n* (%)					
Female	312 (36.1)	86 (33.5)	34 (35.4)	192 (37.6)	0.529
Age (years), median (IQR 25,75)	68 (58,79)	64 (51,73)	66 (50,75)	72 (61,82)	<0.001
Initial rhythm, *n* (%)					
Asystole	327 (37.8)	44 (17.1)	16 (16.7)	267 (52.3)	<0.001
PEA	293 (33.9)	84 (32.7)	37 (38.5)	172 (33.7)	0.696
VF/VT	215 (24.9)	118 (45.9)	37 (38.5)	60 (11.7)	<0.001
Unknown, artefacts	29 (3.4)	11 (4.3)	6 (6.3)	12 (2.3)	<0.001
Bystander CPR, *n* (%)					
Yes	514 (59.5)	169 (65.8)	69 (71.9)	276 (54.0)	<0.001
Witnessed, *n* (%)					
Yes	482 (55.8)	172 (66.9)	68 (70.8)	242 (47.4)	<0.001
Any ROSC, *n* (%)					
Yes	130 (15.0)	56 (21.8)	43 (55.2)	31 (6.0)	<0.001
Outcome, *n* (%)					
CPC 1/2	98 (11.3)	93 (36.2)	5 (5.2)	–	<0.001
CPC 3/4	33 (3.8)	28 (10.9)	5 (5.2)	–	<0.001
30-days survival	124 (14.4)	114 (44.4)	10 (10.4)	–	<0.001
CPR-duration, median (IQR 25,75), min	12 (6.22)	12 (7.22)		18 (11,28)	
Transportation-duration, median (IQR 25,75), min			56 (45,67)		

ROSC: return of spontaneous circulation; SD: standard deviation; PEA: pulseless electrical activity; VF/VT: ventricular fibrillation/ventricular tachycardia; any ROSC: a brief (approximately >30 s) restoration of spontaneous circulation that provides evidence of more than an occasional gasp and occasional fleeting palpable pulse; CPC: cerebral performance category.

Table 2
Distribution of "load&go"-criteria within the study population.

	Total	ROSC at the scene	Ongoing CPR on transport	Died on the scene	*p* value
Count (%)	864 (100)	257 (29.7)	96 (11.1)	511 (59.1)	
load&go criteria, *n* (%)					
VF/VT	215 (24.9)	118 (45.9)	37 (38.5)	60 (11.7)	<0.001
Basic life support	514 (59.5)	169 (65.8)	69 (71.9)	276 (54.0)	<0.001
Witnessed collapse	482 (55.8)	172 (66.9)	68 (70.8)	242 (47.4)	<0.001
Age <75 year	574 (66.4)	198 (77.0)	72 (75.0)	304 (59.5)	<0.001
CPR >15 min of ALS	400 (46.3)	94 (36.6)	–	306 (59.9)	<0.001
All "load&go" criteria fulfilled, *n* (%)	55 (6.4)	17 (6.6)	16 (16.7)	22 (4.3)	<0.001

ROSC: return of spontaneous circulation; VF/VT: ventricular fibrillation/ventricular tachycardia.

Table 3
Stratified into "load&go"-criteria YES vs. NO.

Characteristics	Total	"load&go" criteria		"load&go" criteria	
		YES		NO	
		ROSC	No ROSC/transported	ROSC	No ROSC/transported
Count, (%)	864 (100)	17 (2.0)	38 (4.4)	240 (27.8)	569 (65.9)
Gender, *n* (%)					
Female	312 (36.1)	1 (5.9)	10 (26.3)	85 (35.4)	216 (38.0)
Age (years), median (IQR 25,75)	68 (58,79)	60 (47,71)	61 (55,67)	64 (52,74)	71 (61,81)
Initial rhythm, *n* (%)					
Asystole	327 (37.8)	0	0	44 (18.3)	283 (49.7)
PEA	293 (33.9)	0	0	84 (35.0)	209 (36.7)
VF/VT	215 (24.9)	17 (100)	38 (100)	101 (42.1)	59 (10.4)
Unknown, artefacts	29 (3.4)	0	0	11 (4.6)	18 (3.2)
Bystander CPR, *n* (%)					
Yes	514 (59.5)	17 (100)	38 (100)	152 (63.3)	307 (54.0)
Witnessed collapse, *n* (%)					
Yes	482 (55.8)	17 (100)	38 (100)	155 (64.6)	272 (47.8)
Any ROSC, *n* (%)					
Yes	130 (15.0)	7 (41.2)	6 (15.8)	49 (20.4)	68 (12.0)
Outcome, *n* (%)					
CPC 1/2	98 (11.3)	3 (17.6)	1 (2.6)	90 (37.5)	4 (0.7)
CPC 3/4	33 (3.8)	4 (23.5)	1 (2.6)	24 (10.0)	4 (0.7)
30-days survival	124 (14.4)	7 (41.2)	2 (5.3)	107 (44.6)	8 (1.4)
CPR-duration, median (IQR 25,75) min	11 (6.22)	26 (18,33)	31 (27,35)	11 (6.19)	18 (11,28)
Transportation-duration, median (IQR 25,75) min	56 (45, 67)		52 (41, 62)		57 (47,68)

ROSC: return of spontaneous circulation; SD: standard deviation; PEA: pulseless electrical activity; VF/VT: ventricular fibrillation/ventricular tachycardia; any ROSC: a brief (approximately >30 s) restoration of spontaneous circulation that provides evidence of more than an occasional gasp and occasional fleeting palpable pulse; CPC: cerebral performance category.

these, 5 (31.3%) patients were treated with E-ECLS and one (20%) of them survived for at least 30 days after the resuscitation with unfavourable outcome. One (9%) patient, of those who received no E-ECLS treatment (*n* = 11, 68.8%), survived with CPC 2. On the other hand, 80 (83.3%) patients who did not meet the criteria were taken to the hospital under on-going CPR. Of these, 7 (8.8%) patients were treated with E-ECLS, one (14.3%) of these patients had a 30-days-survival with favourable outcome. Furthermore, 7 (8.8%) patients survived 30 days without E-ECLS; 3 patients with favourable and 4 with unfavourable outcome ($p = 0.791$).

The transportation time to hospital admission was in median 53 min IQR (41–62) if the criteria were fulfilled. Otherwise it took a median of 57 min IQR (47–68) ($p = 0.833$).

Within 96 transported patients, 52 (54%) were admitted in hospitals with the possibility to perform E-ECLS, 44 (46%) in the other 5 hospitals. Among these 52 patients who were transferred to hospitals which can provide E-ECLS, 12 (23%) received E-ECLS, executed only in one hospital.

3.4. The not 'under ongoing CPR' transported group

In total 768 (89%) patients were treated on scene. Within this group, all the "load&go" criteria were met by 39 (4.5%) patients. Of these, 22 (2.5%) were declared dead on scene. A sustained ROSC after 15 min was achieved in 17 (2.0%) cases. Even by taking the CPR duration of less than 15 min not as a criterion, 85 (9.8%) patients would have met the criteria to be transported.

"Load&go"-criteria was existent in 62 (7.2%) patients who achieved ROSC at the scene (*n* = 257, 29.7%). Sustained ROSC at the scene in less than 15 min of ALS was achieved in 45 (5.2%) patients and thus not counted as "load&go"-candidates. Only 17 patients who achieved ROSC at the scene could have been counted as "load&go"-candidates. For those in whom sustained ROSC at the scene in less than 15 min of ALS was achieved it took a median of 7 min IQR (3–11) until ROSC after the ambulance arrival.

Not all "load & go" criteria were met by 729 patients (84.4%); in these, ROSC was conceded in 240 (27.8%) cases. The outcome data were not available in 14 cases.

4. Discussion

The one year incidence of "load&go"-candidates in Vienna, according to designated criteria, has been shown in a limited number of OHCA victims (*n* = 55, 6.4%). Among these, 16 patients were transported with on-going CPR, 17 achieved ROSC after 15 min of ALS and 22 patients deceased at the scene. However, many more patients were brought to the ED with on-going CPR (*n* = 96). Within this one-year observation period, 12 adult patients were treated with E-ECLS at the ED. But only 5 of the E-ECLS patients met the designated "load&go"-criteria and two of all

E-ECLS patients survived 30 days. The majority of patients who were transported with on-going CPR to the ED and who were treated with E-ECLS did not meet all criteria.

Due to the perfect collaboration of emergency physicians, paramedics and field supervisors of the Municipal Ambulance Service with our data recording team we were able to follow all cases during the observation period. After exclusion of cases with patients less than 18 years of age and those without sufficient documentation, a high number of patients ($n = 864$, 91%) could be enrolled. This nearly complete and robust sample size allows drawing valid conclusion with regards towards a "load&go"-strategy for cardiac arrest victims in Vienna. For this observational study the introduced database was not specifically and thus only assumptions can be made retrospectively. As described in the method section, only the patients in whom data were not ambiguous were enrolled. With this approach however, it has to be considered, that only the minimum number of "load&go"-candidates was discovered. Unfortunately, there are no studies which deal with the incidence of "load&go"-patients for E-ECLS to use as comparative value.

The "load&go"-criteria were chosen by reasons of comorbidity reflected by age, association with better outcome after E-ECLS and the possibility for a reversible cause of the arrest.[16] The low age and an initially shockable rhythm might be encouraging factors for higher survival rates.[19] In some trials, a missing bystander CPR was shown as exclusion criteria for an E-ECLS treatment.[7–9,14] Morrison et al. recommend a transport under on-going CPR for paramedics if following criteria are fulfilled: ROSC at any point during resuscitation, shockable rhythm, EMS or bystander-witnessed collapse and bystander CPR.[20] The AHA guideline 2010 recommends (Class IIb, LOE C) to consider an E-ECLS treatment if E-ECLS is available for short no-flow-time or if a reversible cause such as accidental hypothermia or intoxication is likely or revascularization is amenable.[16] The designated criteria are supporting advanced resuscitation efforts and a transport under on-going CPR by disregarding the termination-of-resuscitation-rules.[20–23] The ERC-guideline 2010 recommends criteria to consider termination of OHCA according the 'basic life support termination of resuscitation rule'. The rule includes criteria like no ROSC, no shockable rhythm and no witnessed collapse by EMS personnel.[17]

Subsequently, the used criteria could be revised and incorporated in a new resuscitation protocol. In particular, the CPR duration at the scene but also the kind of scene should be considered. From 55 patients who met all criteria, 22 cases took place in public areas. Furthermore, it can be assumed that the required criteria are easier to achieve in a public area (e.g. witnessed collapse and bystander-CPR).[24] Stub et al.[8] report that OHCA in public place is associated with higher rates of transport under on-going CPR (odds-ratio 2.3 [95% CI 1.4–3.5]). The possibility to perform further therapeutic attempts at the hospital like performing coronary angiography under CPR, E-ECLS in the ED or improvement of quality and feasibility of CPR during transport made a regular "load&go"-procedure more attainable.[8,16,25]

As shown in Table 3, patients who did not meet all criteria (in particular: no ROSC after 15 min of ALS) showed a better outcome. A short CPR-duration on scene is associated with better survival and neurological outcome.[8,15,16,26] The mean duration to achieve sustained ROSC was less than 15 min. Reynolds et al.[18] described the first 10–15 min of a conventional resuscitation as most effective. Within this period, >75% of patients with good neurological outcome reached ROSC. These counts are comparable to counts from this observation and suggest that patients, who do not respond to conventional resuscitation efforts within this period, have only a minimum benefit from prolonged-resuscitation efforts or repetition of the same therapy. According to Reynolds, a novel treatment like E-ECLS should be considered in appropriate patients as soon as possible. Therefore, patients who meet the criteria should be transported after a maximum of 15 min of ALS. A prior transportation might be considered if the quality of resuscitation does not decrease by over-hasty transport efforts.

The study population was analyzed assuming the E-ECLS would be a regular used strategy in this protocol. In the observational period, there were two E-ECLS-survivors. This very low number suggests that transport efforts are futile. In our opinion, however, the low number arise by the lack of a real "load&go"-protocol as mentioned in the limitations. The counts are comparable with other studies[5] and might suggests a potential benefit of E-ECLS, which has to be evaluated in further studies. Within the transport group, however, 10.4% of the patients with otherwise unclear outcome survived longer than 30 days.

Some recent literature reports that a short duration to E-ECLS implantation is associated with better outcome.[7,14] Kano et al.[15] reported a target for the installation of E-ECLS in less than 60 min after collapse. Different studies discussing E-ECLS indicate an exclusion criterion if the period between start of resuscitation or time of collapse and installation of the bypass is too long. Mentioned time frames are 45 min from emergency call to hospital arrival or 60 min until installation of E-ECLS.[7,27] A minimization of the low-flow duration before E-ECLS installation as most encouraging factor might be sought. In future, it might be considered to reduce the gap between collapse and E-ECLS treatment by taking the E-ECLS-device to the scene of cardiac arrest.[28]

Our study showed the incidence of patients who could benefit from an E-ECLS treatment, as reported in previous studies.[5,7,8,10,27] There are still some more questions, which need to be answered before implementing our "load&go"-criteria: Are these criteria possibly too narrow or too wide? Should they be converted in a "must exist" (e.g. bystander CPR), or a "should exist" (e.g. CPR duration at the scene)? An extension for the criteria "ROSC at any time during CPR" as recommended by Morrison et al.[20] may also be considered, as well as the location of cardiac arrest.

5. Limitations

There were neither yet a strict "load&go"-protocol nor obligatory criteria for E-ECLS introduced during the observation period. Thus, data represents the current situation without definitely portraying the meaningfulness or amount of the benefit of E-ECLS. The very low number of patients who were transported under on-going CPR and met the criteria allows only speculative conclusions about the outcome. The data show a very diverse group of patients who were transported with on-going CPR. The reasons for the transport in individual cases are not comprehensible. Unfortunately, there were no data on the further treatment of patients (e.g. angiography rate) available. The major limitations in this evaluation were that basically the "wrong" patients were carried, resulting in a difficulty to assess the quality of the criteria. Additionally, only a slim majority of the 96 patients who were transported were taken to a hospital providing E-ECLS, while all 12 E-ECLS-patients were treated at the General Hospital of Vienna. In our opinion, this circumstance is caused by most patients after OHCA being admitted to this hospital, the scientific interests and the well-known option for E-ECLS within paramedics.

6. Conclusion

The existence of patients who would potentially benefit from a transport with on-going CPR and the use of E-ECLS was found. Due to the very low number of eligible candidates, it is urgent to identify them and to treat them suitably. Further promotion of these criteria within the ambulance crews is needed to reduce

futile transportation efforts. A clear course of action, including clear "load&go"-criteria should be introduced in order to minimize the resuscitation duration before E-ECLS installation. There are more studies needed to precisely specify which patients should be transported with on-going CPR and further, receive E-ECLS treatment to determinate who would benefit the most.

Conflict of interest statement

All authors have no financial and personal relationships with other people or organizations that could inappropriately influence (bias) the work. There has been no funding.

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