The presence of gasping predicts long-term survival in out-of-hospital cardiac arrest patients

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Background. The presence of gasping in out-of-hospital cardiac arrest (OHCA) patients predicts short-term prognosis. We performed a retrospective study to evaluate whether the presence of gasping at the time of Emergency Medical Service (EMS) arrival in the case OHCA patients of presumed cardian origin has any impact on six-month survival and/or sustained return of spontaneous circulation (ROSC).
Methods. We collected and analyzed Utstein Style data for all patients resuscitated for OHCA of presumed cardiac origin by the EMS of the Central Bohemian Region from July 1st, 2013 to June 30th, 2014.
Results. During the data collection period, 565 cases of OHCA of presumed cardiac origin were reported. Gasping at the time of EMS arrival was identified in 23.9%. The presence of gasping was associated with a significantly increased frequency of sustained ROSC (48.1 versus 20.7%, $P<0.001$) and six-month survival (40.7 versus 16.7%, $P<0.001$) than in non-breathing patients. Presence of gasping upon EMS arrival has been found to be an independent positive predictor of sustained ROSC (OR 2.51, CI 95% 1.59-3.98, $P<0.001$). The occurrence of gasping at the time of EMS arrival at the scene was significantly related to response time from EMS activation to arrival.
Conclusion. The presence of gasping upon arrival of the EMS for the patient with OHCA of presumed cardiac origin predicts both improves short-term and long-term prognoses.

Key words: gasping, out-of-hospital cardiac arrest, return of spontaneous circulation, long-term survival

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INTRODUCTION

Gasping is an abnormal breathing pattern related to severe cerebral hypoxia. It is commonly seen in cardiac arrest patients and is considered pathognomonic for this cardiovascular catastrophe. It may persist for several seconds to minutes and its presence has been found to be an independent positive predictor of return of spontaneous circulation (ROSC) (ref.[1-3]). Gasping has also been highlighted in the recent guidelines as a phenomenon that Emergency Medical Service (EMS) dispatchers should be made aware of[4]. Dispatchers should be trained to recognize OHCA despite the presence of gasping[5,6]. However, little is known regarding its ability to predict long-term survival. Therefore, we performed a retrospective study to evaluate whether the presence of gasping at the time of EMS arrival in OHCA patients of presumed cardiac origin has any impact on ROSC and long-term (six months) survival. We hypothesized that gasping is associated with an increased occurrence of both outcomes.

METHODS

We performed a retrospective clinical study that was approved by the local ethics committee (Ethics Committee of the 3rd Faculty of Medicine, Charles University in Prague) and was conducted in accordance with the current Helsinki Declaration. Pre-hospital data were derived from the registry of the EMS of the Central Bohemian Region. It is the exclusive provider of primary prehospital emergency care in the Central Bohemian Region of the Czech Republic. The region includes both rural and urban populations, in total 1 315 299 inhabitants, covering an area of 11 015 km^2. A computer search of resuscitated OHCA patients of presumed cardiac origin between July 1st, 2013 and June 30th, 2014 was conducted. A physician was present at all recorded OHCA events in the field. Advanced life support was provided in accordance with current European Resuscitation Council (ERC) Guidelines[4]. Data were recorded following Utstein protocol including the presence of gasping at the time of ambulance car arrival to the OHCA patient. Basic life support (BLS) was considered to have been provided if bystander cardiopulmonary resuscitation (CPR) and/or

phone assisted CPR were performed. The response time was calculated as the period between EMS team activation and EMS team arrival to the patient. All physicians were educated on gasping, which is a mandatory item in the reporting to the healthcare registry of the emergency medical service. The study endpoints were the sustained return of spontaneous circulation (ROSC) and six-month survival. The latter was recorded from the database of the administrative insurance registries, in accordance with the local laws, and it was obtained only in an aggregated form. Sustained ROSC was defined as return of circulation for at least 20 min.

Statistical Analysis

The data were described as means ± standard deviations (SDs) or percentages as necessary. Differences between groups were compared using the $\chi 2$ test, Fischer exact test for alternative variables and paired t-tests.

Univariate analysis and multivariate logistic regression were performed to assess the association between the presence of gasping and spontaneous circulation upon hospital arrival. Six-month survival data enabled only univariate $\chi 2$ test assessment. The occurrence of gasping in relation to response time was evaluated in quartiles. Microsoft Excel 2007 (Microsoft, Redmond, WA, USA) and JMP 3.2 statistical software (SAS Institute, Cary, NC, USA) was used. A P value of < 0.05 was considered statistically significant.

RESULTS

Of the 877 OHCA cases (incidence 66.7/100 000 inhabitants/year), 565 were of presumed cardiac origin (incidence 43.0 cases/100 000 inhabitants/year).

Gasping at the time of EMS arrival was identified in 23.9% of all OHCA cases. Table 1 provides baseline clinical characteristics of the cardiac arrest patients with

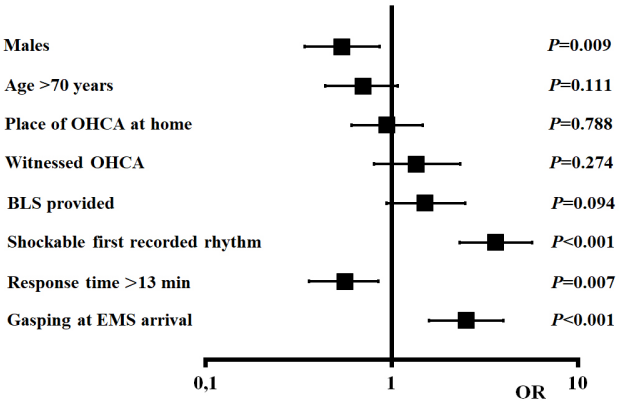

Fig. 1. Multivariate logistic regression of independent predictors of sustained ROSC.
ROSC...return of spontaneous circulation, OHCA...out-of-hospital cardiac arrest, BLS...basic life support, EMS...Emergency Medical Services

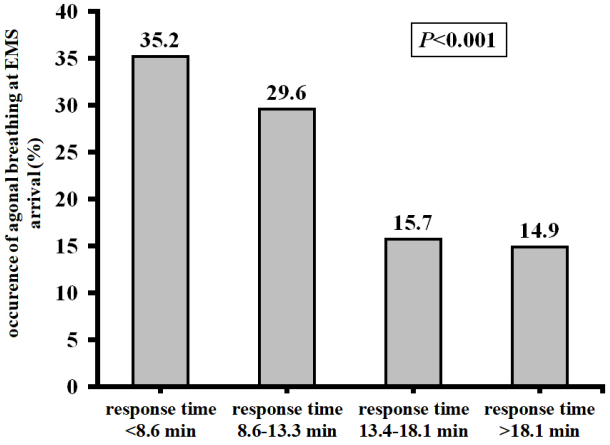

Fig. 2. Occurrence of gasping at the EMS team arrival time over response time.

Table 1. Baseline clinical characteristic of the patients.

	Gasping present	Gasping absent	*P*
n (%)	135 (23.9)	430 (76.1)	<0.001
Males (n (%))	92 (68.1)	298 (69.3)	0.831
Age (years ±SD)	66.2±13.4	67.9±13.1	0.191
Place of OHCA (n (%))			
Home	81 (60.0)	308 (71.6)	0.015
Street	29 (21.5)	69 (16.0)	0.179
Public building	11 (8.1)	18 (4.2)	0.117
Work/office	2 (1.5)	10 (2.3)	0.825
Long-term care	12 (8.9)	25 (5.8)	0.284
Witnessed collapse (n (%))	119 (88.1)	315 (73.3)	<0.001
BLS provided (n (%))	87 (64.4)	311 (72.3)	0.084
First recorded rhythm VF/VT (n(%))	62 (45.9)	93 (21.6)	<0.001
Response time (min±SD)	11.8±7.3	15.9±10.5	<0.001
Sustained ROSC (n (%))	65 (48.1)	89 (20.7)	<0.001
Six month survival (n (%))	55 (40.7)	72 (16.7)	<0.001

OHCA...out-of-hospital cardiac arrest, BLS...basic life support, VF...ventricular fibrillation, VT...ventricular tachycardia, ROSC...return of spontaneous circulation

presumed cardiac origin. The majority of those presenting with gasping when the EMS team arrived had experienced cardiac arrest at home, their arrest was significantly more likely to be witnessed, accompanied by shockable rhythm and associated with shorter response time. Moreover, gasping during the initial assessment was associated with a significantly increased frequency of sustained ROSC (48.1 versus 20.7%, $P<0.001$) and six-month survival (40.7 versus 16.7%, $P<0.001$) than in patients without any breathing activity.

Fig. 1 demonstrates the results of the multivariate logistic regression analysis of the ROSC predictors. Presence of gasping upon EMS arrival was found to be an independent positive predictor of sustained ROSC (OR 2.51, CI 95% 1.59-3.98, $P<0.001$). While shockable first recorded rhythm predicted sustained ROSC as well (OR 3.61, CI 95% 2.32-5.66, $P<0.001$), and a response time longer than 13 min predicted CPR failure (OR 0.56, CI 95% 0.36-0.85, $P=0.007$).

The occurrence of gasping at the time of EMS arrival at the scene was significantly related to response time (Fig. 2).

DISCUSSION

The main finding of our study was that the presence of gasping at the time of EMS arrival at the scene was associated with increased chances of ROSC and improved long-term survival.

Out-of-hospital cardiac arrest has become a general epidemiological issue in European countries. Recently, the incidence of OHCA was reported as 84.0 per 100 000 inhabitants / year in the EuReCa ONE study[7]. This most serious cardiovascular catastrophe often unexpectedly, affects people of working age. Therefore, ongoing and significant efforts must be expended to improve the results of cardiopulmonary resuscitation and to return as many of OHCA victims to a normal life of high health-related quality.

Gasping has been defined as an abrupt, sudden and transient inspiratory effort. In combination with unconsciousness it is considered a pathognomonic sign of cardiac arrest[8,9]. It is a common mammalian pattern of breathing based on the simple brain stem reflex expressed in the setting of cerebral hypoxia[10]. The beneficial effect of gasping on circulation and gas exchange during cardiac arrest has been described[11-14]. It has been formerly hypothesized that gasping is a protective mechanism for anoxia during delivery of immature animals[10].

The reported incidence of gasping fluctuates between 33 and 60% in all OHCA patients[1,15,16]. In our study, gasping was identified only in 23.9% of all OHCA cases. This is a lower incidence than reported in other epidemiological studies. However we focused only on OHCAs of cardiac etiology with a high incidence of witnessed cases, which can impact reaction time. Bobrow et al. reported a 39% incidence of gasping in an unselected group of OHCA patients when the reported time of collapse to EMS arrival was below 10 min. However, in our study the response time (a time from dispatch to the arrival to the scene) was more than 10 min. The dependence of gasping on response time has been clearly demonstrated in our study (Fig. 2) and also in Bobrow's study[1].

It has been described that gasping occurs more commonly in OHCAs with shockable initial rhythm than in the patients with non-shockable rhythm[1,17]. We also observed in our study that more than half of the patients presenting gasping exhibited shockable initial rhythm.

It has been reported that the presence of gasping at the time of CPR initiation is associated with increased chances of ROSC and survival to hospital discharge[1,2]. Zhao et al. conducted a meta-analysis evaluating the impact of gasping on short-term outcome. They found that patients who were gasping were 3.5 times (95% CI 3.0-4.1; $P<0.01$) more likely to survive to discharge than those without gasping and that the presence of gasping predicts ROSC (OR 2.2; 95%CI 1.7-2.8; $P=0.02$) (ref.[18]). In our study, we verified this latter finding and confirmed the findings of the independent positive prediction of ROSC when gasping is present. However, according to our knowledge, no data have been previously published about the impact of gasping on long-term prognosis. Our observation that gasping may have a long-term positive prognostic value for cardiac arrest, stresses the importance of this phenomenon and emphasizes the need for the immediate and correct recognition of gasping by EMS dispatchers and by the EMS teams. We also believe that these patients should be considered for prolonged resuscitation efforts at least until gasping is present. They should also be considered as candidates of transport to extracorporeal cardiopulmonary resuscitation.

Although gasping is a strong prognostic marker, the question remains whether it causally impacts gas exchange during cardiac arrest and intra-arrest circulation or whether it is only an epiphenomenon that simply reflects a higher resistance to hypoxia. It is likely that both alternatives are involved. It has been observed that intrathoracic pressure fluctuations during inspiratory and expiratory periods of gasps induce regular changes of intraaortic and right atrial pressure which generate some degree of cardiac output and cerebral perfusion in untreated experimental cardiac arrest[14,19-20].

The strong impact of gasping on long-term prognoses confirms the need for further research. Questions that should be addressed are: what is the occurrence of gasping immediately after the onset of OHCA and why in some patients (after excluding patients with brain traumatic injury or stroke) gasping is not present? Is gasping a single pathophysiological uniform response or are there more independent differing patterns of gasping, for example, the frequency of gasps? Is there a different hemodynamic effect of gasping in patients with ventricular fibrillation and in patients with nonshockable rhythm? Particularly in the case of patients presenting pulseless electrical activity and preserved minimal spontaneous coordinated left ventricular contractions (known as pseudoPEA) gasping may augment spontaneous left ventricular activity[21]. Should OHCA patients presenting gasping be provided with standard life support with compression-ventilation

ratio 30:2 or resuscitation by the continual compression only technique? Otherwise, when advanced life support is provided should the patient be intubated and mechanically ventilated or should spontaneous ventilation by gasping, without secured airways be a preferred option?

Study limitations

There are several limitations in the present study. First, it is a retrospective survey primarily based on the EMS registry data. However, the data is routinely collected uniformly following Utstein Style. Second, long-term survival data were obtained only in an aggregated form, respecting the local law. Thus, only univariate analyses could be performed. Third, in a significant number of patients it was not possible to reliably determine the time from collapse to EMS arrival. Therefore, we used in the analysis the time from EMS team activation to EMS team arrival to the patient.

CONCLUSION

In conclusion, the presence of gasping at the time of EMS team arrival to the patient with OHCA of presumed cardiac origin is a very strong prognostic marker, not only of achievement of sustained ROSC but also of long-term survival. It puts an imperative emphasis on the recognition of gasping both by EMS dispatchers and EMS ambulance teams. Also, further research leading to a better understanding of the pathophysiology of gasping and its optimal utilization during cardiopulmonary resuscitation is needed.

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