Resuscitation 120 (2017) 57–62

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Characteristics and outcome of patients with hypothermic out-of-hospital cardiac arrest: Experience from a European trauma center☆

Elfriede Ruttmann[a], Marion Dietl[a], Tobias Kastenberger[b], Rene El Attal[c], Mathias Ströhle[d], Hanno Ulmer[e], Peter Mair[d,*]

[a] Department of Cardiac Surgery, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria
[b] Department of Trauma Surgery, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria
[c] Department of Trauma Surgery, Academic Teaching Hospital Feldkirch, Carinnagasse 47, 6800 Feldkirch, Austria
[d] Department of Anaesthesiology and Intensive Care Medicine, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria
[e] Department of Medical Statistics, Informatics, and Health Economy, Medical University of Innsbruck, Schoepfstrasse 41, 6020 Innsbruck, Austria

ARTICLE INFO

Article history:
Received 24 April 2017
Received in revised form 3 July 2017
Accepted 29 August 2017

Keywords:
Hypothermia
Out-of-hospital cardiac arrest
Outcome
Extracorporeal life support
CT scan
Restoration of spontaneous circulation

ABSTRACT

Background: Aim of the study was to investigate patient characteristics, survival rates and neurological outcome among hypothermic patients with out-of-hospital cardiac arrest (OHCA) admitted to a trauma center.
Methods: A review of patients with OHCA and a core temperature ≤32 °C admitted to a trauma center between 2004 and 2016.
Results: Ninety-six patients (mean temperature 25.8 °C ± 3.9 °C) were entered in the study, 37 (39%) of them after avalanche burial. 47% showed return of spontaneous circulation (ROSC) prior to hospital admission. Survival with Glasgow-Pittsburgh Cerebral Performance Category (CPC) scale 1 or 2 was achieved in 25% of all patients and was higher in non-avalanche than in avalanche cases (35.6% vs 8.1%, p = 0.002). Witnessed cardiac arrest was the most powerful predictor of favourable neurological outcome (RR: 10.8; 95% Confidence Interval: 3.2–37.1; Wald: 14.3; p < 0.001), whereas ROSC prior to admission and body core temperature were not associated with survival with favourable neurological outcome. Cerebral CT scan pathology within 12 h of admission increased the risk for unfavourable neurological outcome 11.7 fold (RR: 11.7; 95% CI: 3.1–47.5; p < 0.001). Favourable neurological outcome was associated lower S 100-binding protein (0.69 ± 0.5 μg/l vs 5.8 ± 4.9 μg/l, p 0.002) and neuron-specific enolase (34.7 ± 14.2 μg/l vs 88.4 ± 42.7 μg/l, p 0.004) concentrations on intensive care unit (ICU) admission.
Conclusions: Survival with favourable neurological outcome was found in about a third of all hypothermic non-avalanche patients with OHCA admitted to a trauma center.

Introduction

Out-of-hospital cardiac arrest (OHCA) in patients with accidental hypothermia has several unique features [1–4] and the use of extracorporeal circulation for circulatory support and rewarming (eCPR) is the standard of care for patients not responding to advanced life support (ALS) CPR [1,4,5]. Several reports describing patient characteristics and outcome of eCPR in hypothermic OHCA have been published during the last years [6–9]. However, little is known about characteristics and outcome of patients with restoration of spontaneous circulation (ROSC) prior to hospital admission. Furthermore, patients with OHCA after avalanche burial, near-drowning or severe injuries admitted to a trauma center may be particularly prone to increased mortality and poor neurological outcome [10–12].

To clarify the influence of accidental hypothermia on the outcome of OHCA in a trauma population, we studied characteristics, survival rate and neurological outcome in patients with hypothermic OHCA admitted to the emergency room (ER) of a Central European level 1 trauma center.

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2017.08.242.

* Corresponding author.
E-mail address: p.mair@tirol-kliniken.at (P. Mair).

http://dx.doi.org/10.1016/j.resuscitation.2017.08.242
0300-9572/

Material and methods

After Institutional Review Board approval the study was conducted at the Medical University of Innsbruck, the tertiary referral hospital and level I trauma center for Western Austria. In the study region patients with OHCA are routinely served by physician-staffed emergency medical services (EMS), and ALS CPR is started already at scene in all arrested patients. According to regional EMS protocols, hypothermic patients without ROSC at scene were transported to the Medical University of Innsbruck for extracorporeal life support (ECLS). In the ER, patients without ROSC were selected for ECLS based on their history, plasma potassium concentrations and, in the case of avalanche burial, using the triage algorithm of the International Commission for Alpine Rescue (ICAR) [12]. Patients developing a stable cardiac rhythm on ECLS were not weaned, but supported for another 24–48 h to avoid cardiorespiratory failure [13]. Later during the study patients were routinely kept on mild hypothermia (34 °C–36 °C) for at least 12 h. Patients with ROSC prior to admission were not rewarmed with ECLS, but treated non-invasively using forced air rewarming. According to EMS triage protocols patients with ROSC at scene and a history of accident (alpine sports-related, near-drowning and avalanche burial) were admitted to the trauma ER, patients with ROSC at scene suffering from urban hypothermia or intoxication were admitted to the general ER and thus not included in the study. All hypothermic patients with ongoing CPR who were candidates for eCPR were admitted to the trauma ER.

Patients surviving to ICU admission underwent a whole body CT scan within 12 h of ER arrival. Low-density generalized cerebral edema with sulcal effacement and attenuation of grey matter/white matter interface on cerebral computed tomography (CT) scan was taken as indicator for ischemic brain injury.

Patients

Patients admitted to the trauma ER between 1 January 2004 and 1 April 2016, who also received an ICD-10 (International Classification of Diseases code) of T 68 ("accidental hypothermia") together with a documented core temperature ≤32 °C, were screened for the presence of OHCA with or without ROSC prior to admission. Those patients with OHCA were included in the study and demographic data, presence and pattern and severity of additional traumatic injuries, body core temperature on admission and reason for hypothermia were obtained. Because of the unique pathophysiology and known poor prognosis of avalanche burial, the mechanism of hypothermia was categorized as avalanche or non-avalanche. Non-avalanche cases were divided into exposure and near-drowning cases. Hypothermia was defined as moderate (32°–28 °C) and severe (<28 °C) according to international recommendations [1,2]. Prehospital data included: first documented heart rhythm at scene, history of witnessed cardiorespiratory arrest, burial time and submersion time in avalanche and near-drowning cases and time to ROSC in patients successfully resuscitated at scene. In-hospital data included: pH, base excess, plasma lactate and potassium on admission, strategy of rewarming, time to reperfusion on ECLS, neuron-specific enolase (NSE) and S 100-binding protein (S-100BP) concentrations on ICU admission and cerebral CT scan findings immediately after hospital admission.

Primary outcome measure was survival to hospital discharge with favourable neurological outcome, defined as Glasgow-Pittsburgh Cerebral Performance Category Scales 1 (good cerebral performance, leading a normal life) and 2 (moderate disability, sufficient cerebral function for independent activities of daily life). Secondary outcome measures were ROSC prior to hospital admission and survival to hospital discharge.

Statistical analysis

Statistical analysis was performed using SPSS statistical software, version 24.0 (IBM SPPS Inc.). Continuous data are presented as mean and standard deviation of mean; categorical variables were expressed as frequency and percentage. Continuous variables were tested with Student's T test or the Mann-Whitney *U* test (if assumption of a Gaussian distribution was not fulfilled). For univariate differences in categorical variables, the Pearson chi-square test was applied. Possible associations between survival with favourable neurological outcome and clinical features were assessed by means of univariate analysis. In a second step, multivariate logistic regression analysis was performed to identify independent predictors for favourable neurological outcome. Relative Risk (RR) and 95% Confidence Intervals (CIs) were determined. The selection of variables was based on univariate comparisons (entry criteria $p < 0.05$) and inclusion of clinically relevant variables. Wald statistic was used to assess the strength of the association of risk factors relative to other risk factors. A receiver operating characteristic analysis (ROC) was performed to identify cut-off values for NSE and S-100BP together with corresponding sensitivity and specificity.

Results

Between 1 January 2004 and 1 April 2016 210 (2%) of a total of 9769 trauma ER admissions received the ICD-10 code "accidental hypothermia" and had a documented core temperature ≤32 °C. Almost half (n = 101, 48%) of these 210 hypothermic patients had a history of OHCA with or without ROSC prior to hospital admission. Ongoing CPR efforts were discontinued immediately after arrival in the ER without any intervention in five patients, who were excluded from further analysis. The remaining 96 hypothermic patients with OHCA were entered in the study (66 male, 30 female, age mean ± SD 41.4 ± 21.9, body core temperature mean ± SD 25.8 °C ± 3.9 °C).

Patient outcome

Characteristics of all 96 patients are summarized in Table 1. Therapeutic interventions and patient outcome are shown in Fig. 1. Overall hospital survival was 41.7%, hospital survival with favourable neurological outcome (CPC 1 or 2) was 25%. Witnessed cardiac arrest was the most powerful predictor for survival with favourable neurologic outcome (RR: 10.8; 95% Confidence Interval: 3.2–37.1; Wald: 14.3; $p < 0.001$) whereas avalanche burial was an independent predictor of poor outcome (RR: 0.24; 95% CI: 0.07–0.90; Wald: 4.4; $p = 0.036$). ROSC prior to ER admission and body core temperature were not predictive for hospital survival with favourable neurologic outcome.

Avalanche cases

Patients resuscitated after avalanche burial had a significantly higher mortality than did patients with hypothermic OHCA due to other reasons (survival rate 8.1% versus 35.6%, $p = 0.002$). Of 37 avalanche cases 18 (48.6%) had pre-hospital ROSC, two survived long term with CPC 1. Nineteen (51.4%) patients were resuscitated with ECLS; thirteen had restoration of a perfusing rhythm on ECLS, one with witnessed OHCA after extrication survived long term with CPC 1 (Fig. 1). Avalanche victims with ROSC prior to admission had a significantly higher body core temperature and a significantly shorter duration of snow burial. ROSC prior to hospital admission was associated with a higher rate of survival to hospital discharge, but survival with favourable neurological outcome was not different from avalanche victims resuscitated with ECLS (Table 2).