Resuscitation 102 (2016) 110–115

Contents lists available at ScienceDirect

Resuscitation

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

Clinical paper

SOFA score to assess the severity of the post-cardiac arrest syndrome☆

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ARTICLE INFO

Article history:
Received 12 January 2016
Received in revised form 17 February 2016
Accepted 1 March 2016

Keywords:
Out-of-hospital cardiac arrest
Post-cardiac arrest syndrome
Cardiopulmonary resuscitation
Outcome assessment
SOFA score
Multiple organ failure

ABSTRACT

Aim of the study: The aim of the study was to assess the prognostic impact of organ failures at ICU admission after out-of-hospital cardiac arrest (CA) according to the SOFA score.
Methods: We performed a retrospective analysis of a prospective cohort of all adult patients admitted to a 15-bed medical ICU in a university-affiliated hospital after an out-of-hospital CA. In addition to demographic and clinical data, initial illness severity was measured using the SOFA score. Outcomes (mortality and neurological prognosis) were also collected at day 28 and one year.
Results: A total of 304 patients (age: 66 ± 16 years, male: 55%) were admitted for post-CA management. An initial nonshockable cardiac rhythm was recorded in 274 (90%) cases. At admission, SOFA score averaged 9.8 ± 3.1 for the entire cohort (8.1 ± 3.3 for day 28 survivors versus 10.1 ± 3.1 for non-survivors, $p < 0.001$). At day 1, SOFA remained significantly ($p < 0.001$) higher in nonsurvivors (9.8 ± 3.8) when compared to survivors (6.5 ± 4.1). Death occurred in 269 (88%) and 275 (90%) patients within the 28-day and one-year period, respectively. Neurological outcome at one year was favorable (CPC score 1–2) in 23patients (8%). Multivariate analysis identified the SOFA score at admission as independently associated with mortality at day28 (OR per point of SOFA score 1.17; 95% CI 1.01–1.35; $p = 0.03$).
Conclusions: In the present study, early organ failures, as assessed by the SOFA score at ICU admission, were independently associated with day 28 mortality. SOFA score may help clinicians objectively evaluate the severity of the post-CA syndrome.

Introduction

Out-of-hospital cardiac arrest (CA) remains a major cause of death in industrialized countries.[1] Asystole and pulseless electrical activity (i.e. nonshockable cardiac rhythms), associated with the worst outcomes, are the most frequent first documented heart rhythms after CA.[1,2] Despite improvements in prehospital management and the regular circulation of international guidelines, less than 30% of cardiopulmonary resuscitation (CPR) attempts lead to restoration of spontaneous circulation (ROSC).[1,2] Among patients admitted to the hospital, less than 10% will be discharged without significant neurofunctional sequelae.[1,3,4]

Patients resuscitated from out-of-hospital CA usually develop a post-CA syndrome resulting in early in-hospital mortality.[5,6] This syndrome is related to four key components, i.e. brain injury, myocardial dysfunction, global ischemia–reperfusion (I/R) phenomenon, and persistent precipitating pathology.[5] The severity of these components often leads to multiple organ failure (MOF) contributing to low survival rates.[5] This "postresuscitation disease" shares many features with other systemic inflammatory responses in critically ill patients and has also been described as a sepsis-like syndrome.[7]

Although the definition of the post-CA syndrome is widely accepted, there is no recommended assessment tool to routinely measure its severity. The Sequential Organ Failure Assessment (SOFA) score was initially developed to describe organ dysfunctions in sepsis patients.[8] It has since become the first scoring system for patients with MOF in ICUs (whatever the etiology), given its relatively high specificity and sensitivity to predict prognosis in critically ill patients.[8–12] The objective of the present study was to investigate whether early organ failures, as assessed by the SOFA score at ICU admission, were independently associated with the prognosis after out-of-hospital CA.

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2016.03.001.

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http://dx.doi.org/10.1016/j.resuscitation.2016.03.001
0300-9572/

Methods

Study design

We conducted a retrospective analysis of a prospective cohort investigation of all adult patients admitted following an out-of-hospital CA (from January 2004 to January 2014) in a 15-bed university-affiliated medical ICU. The study received approval from the local ethics committee (*Comité de Protection des Personnes Sud-Est II*). This institutional review board waived the need for consent given the retrospective and non-interventional design of the project.

Data collection

All adult patients admitted to the ICU after an out-of-hospital CA during the study period were included. CA was characterized according to the Utstein style.[13] Additional data were also collected: McCabe scale, comorbidities, clinical and biological data at admission, Simplified Acute Physiology Score II (SAPS II) and organ supports at admission.

The SOFA score, having a range of 0–4 points for each of the 6 organs dysfunctions (respiratory, coagulation, hepatic, cardiovascular, neurologic and renal), was used to describe CA-induced organ failures.[8–11] For this, the following data were collected: need of mechanical ventilation and the arterial partial pressure of oxygen to fraction of inspired oxygen (PaO_2/FiO_2) ratio, platelets, bilirubin, mean arterial pressure and doses of adrenergic agents, Glasgow coma score, creatinine and urine output.[8] The SOFA score was assessed at ICU admission and at day 1, 2, 3, and 7 following CA. In patients who survived at least 24 h, we also calculated the ΔSOFA, defined as the change in SOFA score over the first 24 h (SOFA at 24 h minus SOFA at admission). As previously described, for the analysis of individual organ systems, an organ failure was defined as a SOFA sub-score of 3–4 points.[9–12]

Good neurologic outcome was defined as a cerebral performance category (CPC) score of 1–2.[13] Mortality and neurologic outcome were assessed at both day 28 and one year.

Statistical analysis

Values are presented as mean ± standard deviation (SD) or number (%), as appropriate.

Univariate comparisons were performed using Mann–Whitney *U* test for continuous variables and Chi-2 or Fisher's exact test for categorical variables, as appropriate.

To assess the potential influence of time, patient characteristics and outcomes were compared over two time periods: before and after the dissemination of the 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[2]

The independent contribution to mortality by parameters available at admission and which possibly influenced the day 28 outcomes was analysed by a backward stepwise multivariate analysis using a logistic regression model. Following univariate analysis, all variables with $p < 0.15$, as well as those with a known association with survival (i.e. age, initial cardiac rhythm and therapeutic hypothermia) were included in the initial model. We set the p value >0.10 to eliminate confounding factors from the regression equation. Odds ratios (OR) were estimated with 95% confidence intervals (95% CI). Because of the colinearity with the SOFA score, we did not input any physiological or biological data linked to organ failures into the model as a stand-alone variable. Accordingly, we performed two multivariate models including either the total SOFA score or the SOFA sub-scores (all of them forced into the model).

Survival curves were generated by means of Kaplan Meier estimates and differences were compared using the Log-rank test.

MedCalc Statistical Software version 12.1.2 for windows (MedCalc Software bvba, Ostend, Belgium) was used for all analysis. A p value <0.05 was considered statistically significant.

Results

Population

During the study period, 304 patients were included. Table 1 shows the characteristics of the patients, the CA and the resuscitation according to the day 28 mortality. Nonshockable initial cardiac rhythm as a result of asphyxia, was the leading cause of CA (Table 1), with an external cause of asphyxia and an acute broncho-pulmonary disease documented in 97 (32%) and 60 (20%) patients, respectively. Mild therapeutic hypothermia was applied in 127 (42%) patients. Data concerning demographics, CA, CPR and mortality rate were not significantly different across the predefined periods of the study timeframe (data not shown).

Organ failures

Clinical and biological data at admission are reported in Table 2. Fig. 1 shows the frequency distribution of the SOFA score in the whole population (Panel A) and in survivors (Panel B). The mean SOFA score at admission was 9.8 ± 3.1, with a significantly lower score ($p < 0.001$) in survivors (8.1 ± 3.3) compared to non-survivors (10.1 ± 3.1). This difference was primarily due to neurological and cardiovascular SOFA sub-scores (Table 2). After exclusion of the neurological component, SOFA score remained significantly lower ($p < 0.01$) in survivors (4.5 ± 3.0) versus non-survivors (6.1 ± 3.0). MOF at admission (i.e. the presence of 2 or more organ failures) occurred in 235 (77%) patients (Table 2), of whom 190 (63%) had at least both neurological and cardiovascular failure.

As shown in Table 3, in addition to traditional factors associated with an unfavorable outcome after out-of-hospital CA (i.e. no flow and low flow durations, location of CA), multivariate analysis identified the SOFA score at admission as being independently associated with day 28 mortality (OR per point of SOFA score 1.17; 95% CI: 1.01–1.35; $p = 0.03$). Among the 6 individual components of the SOFA score, the neurological sub-score was the most highly associated with mortality (OR per point 3.43; 95% CI: 1.34–8.81; $p = 0.01$) (Table 3).

At day 1, the SOFA score remained significantly higher in non-survivors than in survivors (9.8 ± 3.8 versus 6.5 ± 4.1, $p < 0.001$). A similar trend was observed throughout the first 7 days after CA (data not shown). In addition, the ΔSOFA, assessed in the 214 patients alive at day one, was significantly lower in survivors when compared to non-survivors (−1.7 ± 2.6 versus +0.6 ± 3.2, $p < 0.001$).

Outcomes

Short-term mortality was 88% (269/304) at both day 28 and ICU discharge. Among the 35 (12%) survivors, 27 (9%) had a good neurologic outcome. As shown in Fig. 2, survival significantly differed according to the number of organ failures present at admission ($p < 0.001$ according to the log rank test). Most common causes of death were intractable post-CA shock ($n = 122$, 45%) and post-anoxic encephalopathy with treatment withdrawal ($n = 114$, 42%). While the neurological sub-score at admission did not differ according to these causes of death, the extra-neurological SOFA score was significantly higher ($p < 0.0001$) in patients who died from shock (7.4 ± 2.8) when compared to those who died from irreversible