Prognostic Significance of Initial Serum Albumin on Mortality in Out-of-hospital Cardiac Arrest

- 병원외 심정지 예후인자로서 초기 알부민 수치의 유용성 -

2014 년 2 월

서울대학교 대학원

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지도 교수 정 성 구

이 논문을 의학석사 학위논문으로 제출함

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2014 년 1 월

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Abstract

Introduction: The purpose of study is to investigate whether serum albumin concentration on hospital arrival may be associated with the long-term mortality in survivors from OHCA.

Methods: Retrospective analysis of patients who had presumed cardiac cause of arrest and achieved sustained return of spontaneous circulation (ROSC) from prospective OHCA registry was conducted. The individual medical records were reviewed for the data including initial serum albumin. Primary outcome was survival at 6 months. The secondary outcome was cerebral performance category (CPC) at 6 months. Differences of variables between survivors and non-survivors at 6 months after cardiac arrest were analyzed. Albumin was categorized into tertiles as <2.9 g/dL, 2.9 to 3.7 g/dL, and >3.7 g/dL. Hazard ratios (HRs) were estimated using Cox-proportional hazard models in both univariate and multivariate analysis. All prognostic variables with their p value < 0.1 in univariate analysis were used in multivariate analysis for adjustment. Receiver operating curve (ROC) analysis was performed to evaluate the discriminative power of albumin.

Results: Of 547 OHCA patients, 136 patients had presumed cardiac cause of arrest and had sustained ROSC with available initial serum albumin. Survival rate at 6 months was significantly higher in patients with a higher albumin group and neurological outcomes were also more favorable in higher albumin group (log rank test, p <0.05). In a Cox proportional hazard regression analysis, initial serum lactate and albumin was independently associated with 6-month mortality and albumin showed moderate discriminative power for 6-month mortality by ROC analysis (AUC = 0.738, 95% CI 0.652-0.825).

Conclusions: Serum albumin might be associated with long-term mortality and neurological outcome in patients with presumed cardiac cause of arrest and sustained ROSC from OHCA.

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1. Introductions

According to Korea centers for disease control and prevention's report, emergency medical services (EMS)-assessed out-of-hospital cardiac arrests has been increased annually and exceeded over 25,000 in 2010[1]. Although advances in cardiopulmonary resuscitation (CPR) and implementation of CPR guidelines have led to more return of spontaneous circulation, only 8-25% of the patients are discharged alive from hospital[2]. Since the goal of CPR is to return the patient to their pre-arrest functional level, early prognostication is an essential component of post cardiac arrest care[3]. Many biochemical markers have been evaluated to prognosticate the post cardiac arrest victim, such as NSE, S-100B protein, RDW, lactate clearance and ammonia[4-7]. However, there are little pre-arrest or intra-arrest parameters known to be useful in prognostication of post cardiac arrest victims.

Serum albumin is the most abundant blood plasma protein and is also a commonly tested laboratory value in hospitalized patients. It has been associated with morbidity and mortality in various diseases including critical illnesses and also suggested as a reliable prognostic factor[8-10]. In previous animal studies, serum albumin improves vascular function in septic shock model[11] and improves cerebral blood flow during post-resuscitation periods in the asphyxia cardiac arrest model[12]. The proposed mechanisms in those experimental settings include improvement of arterial hyporeactivity, attenuation of ischemia reperfusion injury and anti-inflammatory effects[11,12].

However, the association of serum albumin on outcome of out-of-hospital cardiac arrest (OHCA) patients has not been established yet or previous study has failed to prove the association between albumin and the outcome of OHCA[13]. The purpose of study was to investigate whether serum albumin concentration on hospital arrival may be associated with mortality in survivors from OHCA.

2. Material and Methods

2.1. Study settings

The study was performed in a 950-bed tertiary academic hospital with an annual ED census of 67,000. The institutional review board approved the study and waived the consent.

2.2. Study design & data collection

We retrospectively analyzed a prospective registry database of all consecutive out-of-hospital cardiac arrest victims who presented to a single emergency department (ED) between January 1, 2008 and December 31, 2011. Eligible patients were OHCA victims who had presumed cardiac cause of arrest and achieved sustained return of spontaneous circulation (ROSC) after ED visits. Of those, patients who were younger than 15 years old, had clear signs of death such as presence of decomposition or rigor mortis, had non-cardiac cause of arrest such as trauma, submersion, drug overdose, asphyxia, exsanguination (postpartum, gastrointestinal, aortic rupture), stroke, epilepsy, pulmonary thromboembolism, and septic shock, who had ‘do not resuscitate’ order, who achieved ROSC before ED arrival and who treated with external cardiopulmonary bypass (ECMO) were excluded.

The operational definition of sustained ROSC was organized electrical rhythm with palpable pulse more than 20 minutes. Baseline clinical information including Utstein predictors like age, sex, presence of witness, bystander CPR, EMS response time, and initial rhythm, comorbid diseases, application of therapeutic hypothermia, percutaneous coronary intervention, coronary artery bypass graft, continuous renal replacement therapy, intra-aortic balloon pump, implantable cardioverter defibrillator were abstracted from the registry and medical records. Collected initial laboratory variables were as follows: white blood cell count, hemoglobin, platelet, creatinine, albumin, total bilirubin, prothrombin time (International Normalized Ratio), activated partial thromboplastin time, Fibrinogen, D-dimer, lactate.

All blood samples for laboratory tests were done immediately on ED arrival before achievement of ROSC according to immediate blood sampling protocol for OHCA patients in our institution and laboratory data, which were acquired after ROSC, were excluded. The induction of mild therapeutic hypothermia depended upon the treating emergency physician’s decision assuming favorable prognosis. This study was based on a registry database for OHCA. All OHCA patients are enrolled in the registry. If patients had been enrolled in our registry, study nurses attempted to follow up the disposition from the ED and the status of patients using the medical records for patients who were dead during hospital stay. If the patients were discharged alive or transferred to other facility, the status of the patients were ascertained by the presence of the medical records of the outpatient department 6 months after the ED visit. If the medical records did not exist beyond 6 months of the ED visit, telephone contacts to patients or surrogates for survival and neurological status were conducted.

Primary outcome was survival at 6 months follow-up. The secondary outcome was Cerebral Performance Category (CPC) at 6 months.

2.3. Statistical analysis

Data were expressed as mean ± standard deviation or numbers (%). To compare the differences of variable between survivors and non-survivors at 6 months after cardiac arrest, categorical variables were analyzed using the χ^2 test or Fisher exact test, and continuous variables were analyzed using Student t test or the Mann-Whitney U test as appropriate.

To examine the nature of the relationship between initial serum albumin level and the 6 month mortality, albumin values were categorized into tertiles: less than 2.9 g/dL (albumin tertile1; T1), 2.9 g/dL to 3.7 g/dL (albumin tertile 2; T2), greater than 3.7 g/dL (albumin tertile 3; T3).

Sample size was estimated as follows: Study population was divided into tertiles according to albumin level. However, the survival rate of 1st tertile was 0%. Thus, the population was divided into 2 groups; the first group as first and second tertile, and the second group as third tertile. With 2:1 ratio, assuming a type I error as 0.05, and 95% study power, each survival rate will be 8.9% on first group, and 32.6% on second group, the 112 patients would be needed for the study.

Survival rates and cerebral performance categories at 6 months were stratified according to albumin tertile group and compared using χ^2 test. The cumulative survival rates across albumin tertile groups were assessed with Kaplan-Meier curves and log-rank test.

Cox proportional hazards regression analyses were performed to evaluate the relationship between albumin and survival outcomes while adjusting for Utstein predictors and other risk factors that might confound the relationship between albumin and mortality. The proportional hazard assumption was confirmed through the examination of plots of Schoenfeld residuals. Totally 4 models were tested. Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, witnessed, bystander CPR, initial ECG rhythm, no flow time, low flow time, application of therapeutic hypothermia. Model 3 was adjusted for variables used in model 2 plus comorbid disease. Model 4 was adjusted variables used in age, sex and variables, which were significantly different in univariate analysis. The area under the receiver operating characteristic curve (AUC) was used as a measure of discrimination of serum albumin level for 6-month mortality. All statistical analyses were performed using STATA IC/10.1 (Stata Corp. LP, TX, USA).

3. Results

A total of 547 OHCA patients were brought to ED during the study period and 211 patients were excluded because of presumed non-cardiac cause of arrest. Of the eligible 336 patients, 139 patients had achieved sustained ROSC, 3 were excluded because initial serum albumin level were unavailable.

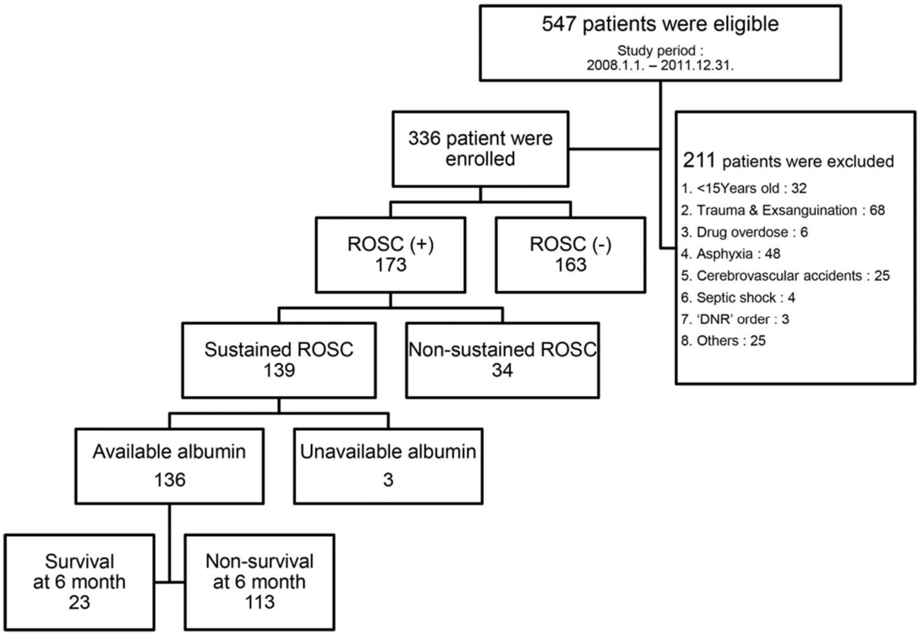

Figure 1. Profile of the eligible study enrolled patient.

As a result, total 136 patients have been enrolled in study (Figure 1). The baseline characteristics of the 136 patients are summarized in Table 1.

	Total patients	Survivors (n=23)	Non-survivors (n=113)	p-value
Age	67.1 ± 16.5	59.0 ± 17.0	68.7 ± 16.0	0.0104
Sex (male, %)	89 (65.4%)	17 (73.9%)	72 (63.7%)	0.349
Witnessed (%)	113 (83.1%)	19 (82.6%)	94 (83.2%)	0.946
Bystander CPR (%)	36 (26.5%)	8 (34.8%)	28 (24.8%)	0.322
Initial ECG rhythm				0.0001
Shockable	21 (15.4%)	10 (43.5%)	11 (9.7%)	
Non-shockable	109 (80.1%)	12 (52.2%)	97 (85.8%)	
Unspecified	6 (4.4%)	1 (4.3%)	5 (4.4%)	
Call to EMS (min)	8.5 ± 4.2	7.8 ± 3.8	8.7 ± 4.3	0.4403
EMS to hospital arrival (min)	16.3 ± 6.6	14.4 ± 5.3	16.6 ± 6.8	0.188
Comorbid disease				
Neoplastic Disease	24 (17.6%)	2 (8.7%)	22 (19.5%)	0.217
Chronic Liver Disease	9 (6.6%)	1 (4.3%)	8 (7.1%)	0.631
CHF	16 (11.8%)	2 (8.7%)	14 (12.4%)	0.616
CVA	20 (14.7%)	0 (0.0%)	20 (17.7%)	0.029
CKD	19 (14.0%)	1 (4.3%)	18 (15.9%)	0.144
Diabetes Mellitus	42 (30.9%)	6 (26.0%)	36 (31.9%)	0.585
Hypertension	58 (42.6%)	15 (65.2%)	43 (38.1%)	0.016
CAD	31 (22.8%)	8 (34.8%)	23 (20.4%)	0.133
COPD	12 (8.8%)	2 (8.7%)	10 (8.8%)	0.981

	Total patients	Survivors (n=23)	Non-survivors (n=113)	p-value
Laboratory findings				
Hemoglobin (g/dℓ)	11.6 ± 3.7	14.2 ± 1.7	11.1 ± 3.7	0.0001
Platelet (x 10^3/μℓ)	194.4 ± 125.3	235.6 ± 111.8	186.0 ± 126.6	0.0839
Creatinine (mg/dℓ)	2.04 ± 1.80	1.29 ± 0.70	2.20 ± 1.91	0.0271
Albumin (g/dℓ)	3.3 ± 0.8	4.0 ± 0.5	3.1 ± 0.7	0.0001
Total Bilirubin (mg/dℓ)	1.44 ± 3.00	0.96 ± 0.39	1.54 ± 3.28	0.4032
PT (INR)	1.89 ± 2.1	1.19 ± 0.23	2.04 ± 2.24	0.0703
aPTT (sec)	56.4 ± 31.7	44.9 ± 35.1	58.8 ± 30.6	0.0537
Fibrinogen (mg/dℓ)	406.3 ± 223.9	353.0 ± 161.7	417.3 ± 233.8	0.2109
D-dimer (μg/mℓ)	10.4 ± 9.2	6.2 ± 9.8	11.2 ± 8.9	0.0169
Lactate (mmol/ℓ)	13.5 ± 5.8	7.6 ± 3.3	14.6 ± 5.5	0.0001
Application of TH (%)	46 (33.8%)	11 (47.8%)	35 (31.0%)	0.119
PCI	8 (5.9%)	5 (21.7%)	3 (2.7%)	0.001
CABG	2 (1.5%)	2 (8.7%)	0 (0.0%)	0.002
IABP	4 (2.9%)	3 (13.0%)	1 (0.9%)	0.002
CRRT	3 (2.2%)	0 (0.0%)	3 (2.7%)	0.429
ICD	3 (2.2%)	3 (13.0%)	0 (0.0%)	0.001

Table 1. Basic characteristics of study population and comparison between survivors and non-survivors

CHF : Congestive Heart Failure, CVA : Cerebrovascular accident, CKD : Chronic Kidney Disease, CAD : Coronary Artery Disease, COPD : Chronic Obstructive Pulmonary Disease, WBC : White Blood Cell, PT : Prothrombin time, aPTT : activated Plasma Prothrombin time, TH : Therapeutic hypothermia, PCI : Percutaneous Coronary Intervention, CABG : Coronary Artery Bypass Graft, IABP : Intra-aortic Balloon Pump, CRRT : Continuous Renal Replacement Therapy, ICD : Implantable Cardioverter Defibrillator

Mean age was 67.1 year and male gender was 89 patients (65.4%). Witnessed cardiac arrest was 113 patients (83.1%). However, bystander CPR was performed only in 36 patients (26.5%) and mean call-to-EMS arrival time was 8.5 ± 4.2 minutes and mean EMS-to-hospital arrival time was 16.3 ± 6.6 minutes. In underlying co-morbid conditions, hypertension (42.6%) and diabetes mellitus (30.8%) were most prevalent. Of baseline laboratory values, leukocytosis, decreased hemoglobin, increased creatinine, elevated coagulation values, and increased d-dimer and lactate were noted. Therapeutic hypothermia was performed in 46 patients (33.1%).

Patient characteristics of the study population were compared according to survivors and non-survivors (Table 1). Initial ECG rhythm, Underlying cerebrovascular diseases and hypertension and laboratory findings such as hemoglobin, creatinine, albumin, d-dimer and lactate were significantly different between two groups.

When patients were divided into three groups according to initial serum albumin, survival at 6 months was higher in higher albumin tertile group (Table 2, p-value < 0.05) and proportion of patients with favorable neurological outcome (CPC 1 or 2) at 6 months was high in higher albumin tertile group (Table 2).

	Total Patients N=136	T1 (<2.9 g/dℓ) N = 46	T2 (2.9~3.7 g/dℓ N = 44	T3 (>3.7 g/dℓ) N = 46	p-value
6 Months survival, No (%)	23 (16.9%)	0 (0.0%)	8 (18.2%)	15 (32.6%)	0.001
Neurological outcome					0.003
CPC 1	14 (10.3%)	0 (0.0%)	3 (6.8%)	11 (23.9%)	
CPC 2	2 (1.5%)	0 (0.0%)	2 (4.5%)	0 (0.0%)	
CPC 3	2 (1.5%)	0 (0.0%)	1 (2.3%)	1 (2.2%)	
CPC 4	5 (3.7%)	0 (0.0%)	2 (4.5%)	3 (6.5%)	
CPC 5	113 (83.1%)	46 (100.0%)	36 (81.8%)	31 (67.4%)	

Table 2. Primary and secondary outcomes stratified according to albumin tertiles.

Kaplan-Meier survival curve with log-rank test showed that increased albumin tertile was associated with an increased survival rates during the 6-months follow-up period (Figure 2, log-rank test p < 0.05).

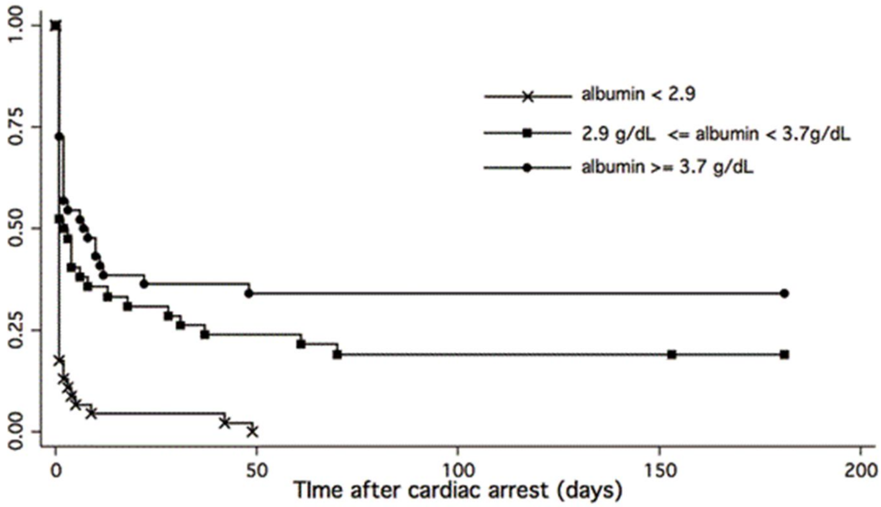

Figure 2. Kaplan-Meier plots for cumulative 6-month survival. The difference was significant according to the log rank test (p<0.05)

In the Cox proportional hazard regression analysis, covariates were added to the model in four steps as described above. After adjustment to each model, patients of lower albumin tertile group had increased mortality. (Table 3, p-value for trend < 0.05 respectively).

	Q1 (<2.9g/dL)	Q2 (2.9~3.7g/dL)	Q3 (>3.7g/dL)	p-value for trend
Model 1	Reference	0.52 (0.32 – 0.82)	0.39 (0.24 - 0.66)	0.001
Model 2	Reference	0.47 (0.27 - 0.81)	0.52 (0.29 - 0.94)	0.024
Model 3	Reference	0.53 (0.33 - 0.85)	0.53 (0.30 - 0.93)	0.015
Model 4	Reference	0.42 (0.22 – 0.79)	0.53 (0.29 - 0.97)	0.047

Table 3. Cox proportional hazard regression analysis for significant variables of univariate analysis.

Model 1: adjusted for age, sex.

Model 2: adjusted for age, sex, witnessed, bystander CPR, initial ECG rhythm, no flow time, low flow time, application of hypothermia.

Model 3: adjusted for age, sex and comorbid diseases (neoplastic disease, chronic liver disease, CHF, CVA, CKD, CAD, COPD).

Model 4: adjusted for age, sex and variables, which were significantly different in univariate analysis.

The AUC of albumin tertile group was 0.738 (95% confidence interval, 0.652 to 0.825, Figure 3), and albumin had moderate discriminative power for 6-months mortality.

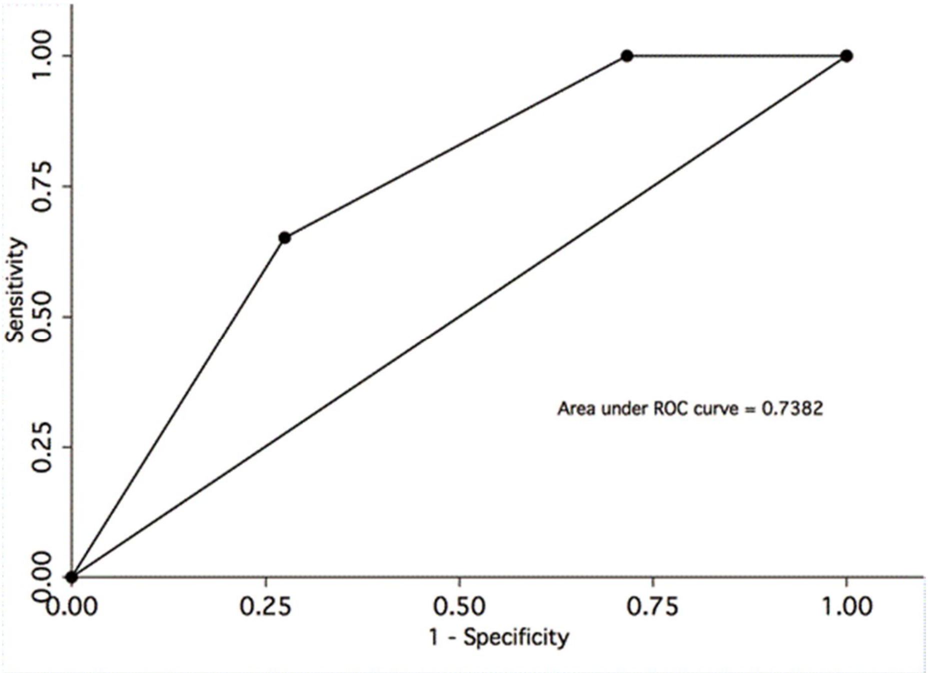

Figure 3. Receiving operating characteristic curve of albumin for 6-month mortality. The area under curve of albumin tertile group was 0.738 (95% confidence interval, 0.652 to 0.825)

4. Discussion

This study suggests that serum albumin at ED arrival is independently associated with survival at 6 months and favorable neurological outcome in OHCA patients who had presumed cardiac cause of arrest and achieved sustained ROSC.

Hypoalbuminemia is known as an independent predictor of adverse outcomes in various diseases. It is a strong predictor of mortality in general population[14)], infection[10)], liver cirrhosis[15)], and cancer[16)]. In our study, low serum albumin level might be derived from underlying comorbid conditions before the onset of cardiac arrest. Therefore, underlying cause of hypoalbuminemia, rather than low serum albumin level itself might be responsible for the result. However, multivariable analysis showed that serum albumin was independently associated with survival at 6 months after adjusting comorbid conditions like cerebrovascular disease and hypertension, which were significantly different between survivors and non-survivors.

A possible hypothesis for the association between low serum albumin and poor outcome in OHCA patients might be due to the protective effects of albumin in ischemia/reperfusion injury. Cardiac arrest represents global ischemic conditions, and its accumulated oxygen debt leads to endothelial activation and systemic inflammation. In the previous animal experiments, serum albumin has been shown to have anti-inflammatory effects[17)] and act as a scavenger of reactive oxygen species and other toxins like leukotoxin[18,19)], which contributes to increased vascular permeability and shock. In addition, it has been reported that serum albumin had effects on blood coagulation and inhibited platelet aggregation similar to heparin[20,21]. Thus, it can improve microcirculation by inhibiting microvascular thrombosis. Alteration of microvascular circulation occurs in cardiac arrest and this might influence outcome[22,23]. Although it could not be concluded that administration of albumin in case of low albumin level would have beneficial effects on global ischemia/reperfusion injury of cardiac arrest, it has been reported that albumin could improve organ perfusion and microcirculation in some experimental studies. Manole et al.[12] have proved that administration of albumin improves cerebral blood flow during post-resuscitation periods in the asphyxial cardiac arrest model. In addition, Meziani et al.[11] have demonstrated that administration of albumin improved vascular reactivity and was associated with a reduced expression of inducible nitric oxide synthase in the vascular wall in sepsis animal model. Thus, higher serum albumin level might improve organ perfusion and microcirculation during post-resuscitation period. Further study will be needed to clarify the effects of albumin administration on organ perfusion and outcomes in post-cardiac arrest.

Cardiac arrest and resuscitation results in systemic inflammation and thus blood concentrations of various cytokines, soluble receptors and endotoxin are increased during and after CPR[24]. It has been reported that albumin synthesis is decreased by interleukin-1 (IL-1)[25] and 6 (IL-6) and tumor necrosis factor-α (TNF-α)[20]. However, half life of albumin is approximately 21 days, considering a 4% daily degradation rate[26]. Thus, considering time relationship, decreased serum albumin concentration during cardiac arrest cannot be explained by cytokine-induced decreased synthesis. In this study, lactate has been shown as an independent predictor of 6-month survival. In previous experimental study, lactate was associated with no-flow or low-flow time in canine arrest model[27]. As lactate is produced in hypoxic state, it may represent prolonged ischemic time. However, serum albumin was independently associated with mortality after adjusting serum lactate level in our study.

In other aspects, there might be a selection bias in our study population. Previous study, which measured serial levels of inflammatory markers including CRP, Interleukin-6, serum amyloid A and serum albumin in hemodialysis patients, showed that serum albumin was decreased 1-2 weeks after clinical inflammatory events[28]. Moreover, it has been reported that lower level of reduced albumin is closely related to serious cardiovascular incidence in dialysis patients[29]. Thus, our findings might be resulted from that patients with lower level of albumin could have more incidents on cardiac arrest than patients with higher level of albumin. However, we could not conclude that cardiac arrest events were more prevalent in patients with lower albumin level than with higher levels. Further studies will be needed to identify the association of serum albumin with incidence of cardiovascular events in general population.

There are studies, which investigated association of albumin level with outcome in OHCA. However, they have failed to prove the independent association between serum albumin and outcome. This might be different with our findings due to subset of patients. Yanagawa et al.[13] included all OHCA patients regardless of achievement of ROSC and excluded patients who have underlying liver and kidney disease. In our study, we included OHCA patients who had presumed cardiac cause of arrest and achieved sustained ROSC regardless comorbid conditions. Achievement of ROSC might be related with many variables such as coronary perfusion during CPR, CPR performance, duration of cardiac arrest and severity of comorbid conditions, etc. Thus, we only included patients who achieved sustained ROSC and prognostication may be more important especially in survived patients from cardiac arrest rather than in all cardiac arrest victims. Cho et al.[30] have investigated the association of blood biomarkers with neurologic outcome in cardiac arrest patients. They have found that serum albumin was significantly different between good neurological outcome and poor neurological outcome in univariate analysis. However, in multivariate analysis, they did not find the significant difference of serum albumin on neurological outcome. This might be also caused by different subset of study participants from our study. They included patients who underwent therapeutic hypothermia successfully. In our study, therapeutic hypothermia was performed only in 46 patients (33.1%). This might have resulted in differences from our study.

This study has several limitations. First, it was conducted in a single institution and only included patients with presumed cardiac cause of arrest and sustained ROSC from OHCA. Thus, it cannot be extrapolated to all patients with OHCA, nor can it be generalized to every cardiac arrest patients. Second, hypoalbuminemia can be caused by various conditions including chronic debilitated disease and malnutrition. Because of retrospective nature of this study, markers of malnutrition like body mass index, prealbumin and skin thickness could not be checked and identified chronic conditions were limited to covariates that were available in the hospital records. Third, the sample size of this study was small considering many variables included in multivariate analysis. Fourth, we did not investigate whether the albumin was replaced according to initial value of serum albumin and whether the replaced albumin affected the clinical course of OHCA victims. Further clinical study will be needed to clarify the beneficial effects of serum albumin and the meaning of initial low serum albumin regarding the severity of illnesses.

5. Conclusion

Serum albumin might be associated with mortality and neurological outcome in patients with presumed cardiac cause of arrest and sustained ROSC from OHCA. Further studies to investigate the protective mechanism of albumin in post-cardiac arrest victims will be needed.

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국문 초록

서론: 병원외 심정지 환자의 장기 예후에 병원 도착시의 환자 알부민 농도가 어떤 연관성이 있을지를 확인하고자 하는 것이 본 연구의 목적이다.

방법: 심인성으로 추정되는 병원외 심정지 환자군 중 자발순환회복을 성취한 군을 후향적 분석하였다. 병원외 심정지로 응급실 내원 환자의 자발순환회복 성취 이전의 초기 혈중 알부민 농도를 포함한 자료를 의무기록을 토대로 자료를 추출하였다. 1 차 결과는 6 개월 후 생존여부로, 2 차 결과는 6 개월 후 신경학적 예후 (Cerebral Performance Category : CPC) 로 판단하였다. 6 개월 후 생존군과 비생존군 사이의 변수들을 비교하였고, 알부민 수치에 따라서 환자를 3 등분하였다. (<2.9 g/dL, 2.9 to 3.7 g/dL, and >3.7 g/dL) 콕스 위험 모형을 통하여 사망위험률을 측정하고, 단변수분석에서 유의한 변화를 보인 변수(p value < 0.1)를 다변수분석에서 보정하여서 확인하였다. 알부민의 변별력을 확인하기 위하여 ROC 분석을 시행하였다.

결과: 547 명의 병원외 심정지 환자중 자발순환회복과 알부민 측정이 유효한 136 명이 확인되었다. 6 개월 후 생존률은 높은 알부민

군에서 더 유의하게 높았고, 신경학적 예후도 더 양호한 것으로 확인되었다. (Log rank test, $p < 0.05$) 콕스 비례 위험 분석에서 젖산 농도와 알부민이 6 개월 후 사망률과 독립적인 연관성을 갖는 것을 확인하였고, ROC 분석을 통해서 중등도의 변별력을 갖는 것을 확인하였다.

결론: 초기 혈중 알부민 농도는 병원외 심정지 환자의 장기 생존률 및 신경학적인 예후와 연관이 있다고 판단된다.

주요어 : 병원외 심정지, 알부민, 신경학적 예후
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