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Original article

Prognostic effect of estimated glomerular filtration rate in patients with cardiogenic shock or cardiac arrest undergoing percutaneous veno-arterial extracorporeal membrane oxygenation

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ABSTRACT

Background: Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) can improve survival in patients with cardiogenic shock or cardiac arrest. We investigated the association between initial renal function and clinical outcome in patients undergoing VA-ECMO for cardiogenic shock and cardiac arrest.
Methods: This was a single-center, retrospective cohort study of 287 patients who underwent ECMO at our hospital from January 2005 to December 2014. We excluded 70 patients with non-cardiogenic events. The remaining 217 patients were divided into 2 groups according to initial estimated glomerular filtration rate (eGFR): Initial high eGFR (non-renal failure: non-RF) group: eGFR $\geq$ 60 ml/min/1.73 m^2 (n = 73) and initial low eGFR (RF) group: eGFR $<$ 60 ml/min/1.73 m^2 (n = 144). Clinical outcome was defined as all-cause death at 30 days after extracorporeal life support.
Results: VA-ECMO was begun in 87% of patients for cardiac arrest. The non-RF group was significantly younger (51.6 vs. 62.6 years), had lower body mass index (22.8 vs. 24.7 kg/m^2), lower blood urea nitrogen (14.4 vs. 23.9 mg/dl), and lower K (4.0 vs. 4.5 mEq/l, all $p < 0.05$) than the RF group. Incidence of all-cause death at 30 days was significantly lower in the non-RF than RF group (49% vs. 76%, $p < 0.0001$). Initial low eGFR was an independent predictor of mortality after adjustment for multiple cofounders (OR: 4.08, 95% CI: 1.77–9.42, $p < 0.001$). Kaplan–Meier curve showed better outcome in the non-RF versus RF group (p = 0.0009).
Conclusion: An initial low eGFR may predict worse clinical outcome in patients undergoing VA-ECMO for cardiogenic shock and cardiac arrest.

Introduction

Extracorporeal membrane oxygenation (ECMO) can provide immediate and adequate systemic circulation and oxygenation in patients with refractory cardiac arrest or cardiogenic shock, and compared with left ventricular assist devices, it is much simpler to operate and requires shorter set-up time [1–3]. The early application of ECMO improves patient prognosis following both prolonged in-hospital cardiac arrest [4] and out-of-hospital cardiac arrest [5,6]. However, there are few data regarding the clinical outcome of patients who are complicated by refractory cardiogenic shock or cardiac arrest and have undergone veno-arterial ECMO (VA-ECMO) [7].

Chronic kidney disease (CKD) is recognized as a large public health problem worldwide [8,9]. Current guidelines provide a classification of CKD stages based on the estimated glomerular filtration rate (eGFR): $\geq$90 ml/min/1.73 m^2 (stage 1), 60–89 ml/min/1.73 m^2 (stage 2), 30–59 ml/min/1.73 m^2 (stage 3), 15–29 ml/min/1.73 m^2 (stage 4), and $<$15 ml/min/1.73 m^2 (stage 5) [10]. CKD is associated with elevated mortality from cardiovascular disease and has been increasingly recognized as an independent risk factor for the development of coronary heart disease [11–13]. In addition, eGFR is an informative prognostic factor among patients with coronary heart disease, independent of other clinical characteristics [14]. A recent meta-analysis showed an abrupt increase in the risk for cardiovascular mortality in a general population of

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patients with stage 3 CKD [12]. However, it is unclear whether CKD increases mortality in patients who undergo VA-ECMO due to cardiogenic shock and cardiac arrest.

Therefore, the aim of this study was to elucidate the association between initial renal function just before implantation and clinical outcome in patients undergoing VA-ECMO due to cardiogenic events.

Materials and methods

Study population

The Institutional Review Board of Tokyo Metropolitan Bokutoh Hospital approved this study. Written informed consent was obtained from the patients or their family members. So as not to waste time, while the ECMO team leader was gathering information and talking with the relatives, the other members of the ECMO team were preparing for ECMO implantation. Between January 2005 and December 2014, 287 patients (58.2 ± 15.5 years, 78% male) received extracorporeal life support (ECLS) at our hospital. We excluded 70 patients receiving ECLS for non-cardiogenic events. The remaining 217 patients with cardiogenic events were enrolled in this study. These patients were further categorized into the following subgroups: (1) acute myocardial infarction (AMI) ($n = 126$); (2) refractory ventricular fibrillation ($n = 49$); (3) acute pulmonary embolism ($n = 16$); (4) fulminant acute myocarditis ($n = 11$); (5) refractory congestive heart failure (CHF) unresponsive to medication ($n = 10$); and (6) post-surgery pump failure ($n = 5$). The rate of out-of-hospital cardiac arrest was 35%, in-hospital cardiac arrest was 52%, and cardiogenic shock was 13% (Fig. 1). We divided the patients into two groups according to their initial eGFR: the non-RF (renal failure) group, comprising patients with an eGFR $\geq$ 60 ml/min/1.73 m^2 ($n = 73$), and the RF group, comprising patients with an eGFR $<$ 60 ml/min/1.73 m^2 ($n = 144$), on the basis of receiver operating characteristics (ROC) analysis. The eGFR values were determined with the following equation: eGFR = 194 $\times$ serum creatinine$^{-1.094}$ $\times$ age$^{-0.287}$ ($\times$0.739 if female) [15].

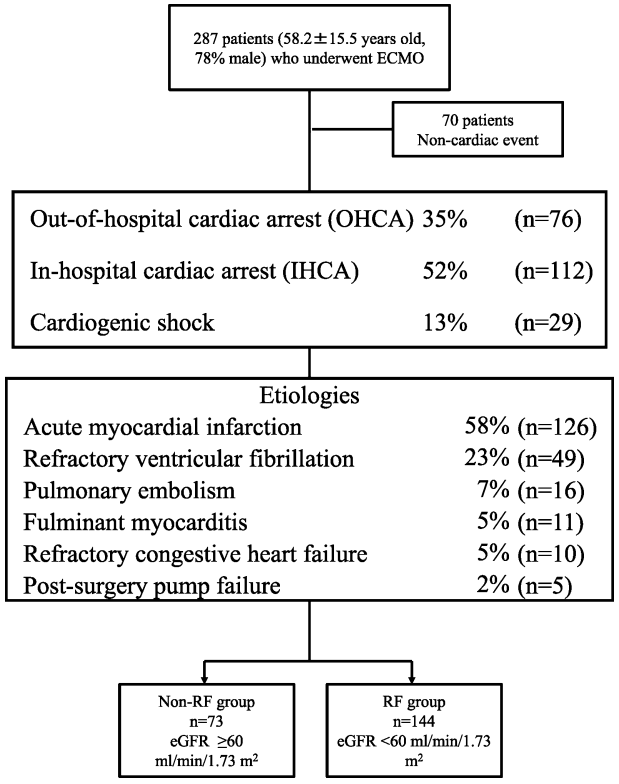

Fig. 1. Flowchart of the study patients undergoing extracorporeal membrane oxygenation. ECMO, extracorporeal membrane oxygenation; eGFR, estimated glomerular filtration rate; RF, renal failure.

ECLS system

The ECLS system consists of a centrifugal pump, a polypropylene hollow-fiber membrane oxygenator, and a circuit that is heparin bonded. We performed ECLS using the Capiox Emergency Bypass System (Terumo Inc., Tokyo, Japan) and the MERA HAS-CFP PCPS system (Senko Medical Instrument Manufacturing Co., Ltd., Tokyo, Japan). We used a 15-Fr or 16-Fr arterial cannula with a length of 15 cm and a 21-Fr or 22-Fr venous cannula with a length of 50 cm, which are inserted into the femoral vessels using the Seldinger technique or cut-down technique. Mechanical circulation is established with venous blood drainage from the right atrium and arterial blood return to the femoral artery. The ECLS team consisted of at least 6 emergency physicians and a cardiologist who stay in the hospital 24 h a day. All physicians were trained to set up the ECLS systems within 10 min. Patients with heart disease who need intensive care are reported to be admitted more frequently during the nighttime than daytime [16]. In our hospital, it is possible to start 3 ECLS systems at the same time 24 h a day, and we can manage 5 ECLS systems simultaneously.

Indications

Relative indications for the introduction of ECLS were the following: (1) refractory cardiogenic shock unresponsive to inotropic agents or intra-aortic balloon pumping (IABP); (2) ventricular fibrillation on electrocardiogram during cardiopulmonary resuscitation with or without witnessed cardiac arrest, which was unresponsive to agents or defibrillation; (3) presumed cardiogenic cardiopulmonary arrest (CPA) on arrival of the rescue team; (4) presumed cardiogenic CPA after patient arrival at the hospital; and (5) presumed cardiogenic CPA with a witness in a patient who can be transported to our hospital within 30 min.

In the above cases, the patients who were 70 years old or younger were indicated to receive ECLS proactively. Patients with a terminal illness and those with a "do not resuscitate" designation were excluded from the study.

Data collection

For the purpose of this study, all patients undergoing ECLS were identified prospectively. Laboratory data, etiology, pre-existing comorbidity, weaning from ECMO, 30-day mortality, and other factors were retrospectively collected from the medical records. We defined door-to-ECMO time as the time from patient arrival at hospital to the time of initiation of ECMO for patients with out-of-hospital cardiac arrest and as the time from arrival of emergency physicians or cardiologists at the patient's bedside to the time of initiation of ECMO for patients with in-hospital cardiac arrest or cardiogenic shock.

ECLS management

The ECLS flow rate was determined based on blood pressure, urine output, Swan-Ganz catheter parameters, and arterial blood gas analysis. Mean arterial blood pressure was maintained at greater than 60 mmHg. Routine intra-aortic balloon pump placement was recommended. However, we did not perform IABP in the following cases: (1) contraindication to IABP; (2) inability to implant owing to the presence of arterial occlusion; (3) withdrawal of intensive therapy for severe neurological damage after ECMO

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