The Impact of Vascular Complications on Survival of Patients on Venoarterial Extracorporeal Membrane Oxygenation

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Background. **There are various factors that can influence the survival of patients receiving venoarterial extracorporeal membrane oxygenation (VA ECMO). Vascular complications from femoral cannulation are common and are potentially serious. We analyzed the impact of vascular complications on survival of patients receiving VA ECMO.**

Methods. **Patients supported with VA ECMO by means of femoral cannulation from October 2010 to November 2014 were enrolled in this study. Data were gathered retrospectively by reviewing our institutional database. Patients were separated into two groups depending on the presence of major vascular complications, defined as patients who required surgical intervention. We evaluated predisposing factors for vascular complications and compared survival of patients in each group.**

Results. **There were 84 patients enrolled in the study. The rates of overall ECMO survival and survival to hospital discharge were 60% and 43%, respectively. Major vascular complications requiring surgical intervention were seen in 17 (20%) patients. Ten patients (12%) had compartment syndrome requiring prophylactic fasciotomy, and 10 patients (12%) had bleeding or hematoma requiring surgical exploration. The only significant predisposing factor for vascular complications was the absence of a distal perfusion catheter (odds ratio, 14.8; $p = 0.03$). The rate of survival to discharge was 18% and 49% in patients with and without vascular complications, respectively ($p = 0.02$). Vascular complications were an independent factor of significantly worse survival in patients receiving VA ECMO by multivariate analysis (hazard ratio, 2.17; $p = 0.02$).**

Conclusions. **Vascular complications negatively affect survival in patients receiving VA ECMO support by means of femoral cannulation. The utilization of a distal perfusion catheter can decrease the incidence of complications.**

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Extracorporeal membrane oxygenation (ECMO) is increasingly used for treatment of patients with critical cardiopulmonary failure [1–4]. Recovery from ECMO largely depends on the underlining disease process as ECMO is only a supportive measure [4]. Major complications of ECMO can include neurologic, cardiac, pulmonary, hemorrhagic, and vascular issues, which lead to serious consequences [5, 6]. The most common cannulation technique for adults requiring venoarterial (VA) ECMO is percutaneous by means of the femoral vessels because of their size and accessibility [4, 7]. However, vascular complications related to femoral cannulation are one of the most common and serious complications of ECMO [5, 6, 8–12]. Leg ischemia is particularly worrisome, and a distal perfusion catheter is often placed to prevent ischemia [13, 14]. The relationship between major vascular complications and outcomes of patients receiving ECMO is still unclear [11, 12]. We have evaluated the impact of vascular complications on survival in patients receiving VA ECMO by means of femoral percutaneous cannulation.

Patients and Methods

Patients

Adult patients (age older than 16 years) supported with VA ECMO by means of femoral percutaneous cannulation from October 2010 to November 2014 were enrolled in this study. Data were collected by retrospectively reviewing medical charts and our institutional database, which was approved by the institutional review board. All patients were included regardless of indication (cardiogenic shock, respiratory failure, or both). Major vascular complications related to cannulation were defined as those that required surgical intervention. Surgical indications include surgical bleeding that required more than 2 units of blood or symptomatic limb ischemia (change in appearance, decrease in oximetry, or loss of pulse). Complications in which surgical intervention was withheld owing to patient death or withdrawal of care

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were counted as major complications. Patients were separated into two groups depending on the presence or absence of major vascular complications. Minor vascular complications managed conservatively were evaluated separately.

Procedure

All cannulation was performed percutaneously at the bedside without fluoroscopy by a modified Seldinger technique unless there was technical difficulty. The size of the cannula was chosen based on desired flow for the patient. A distal perfusion catheter (DPC) was placed routinely at the same time unless there was technical difficulty or the patient was too unstable. A single dose of heparin (5,000 to 7,500 IU) was administered after cannulation. Continuous heparin was started no more than 24 hours after cannulation, aiming for a partial thromboplastin time goal of 45 to 55 seconds [7].

When the patient had clinically improved, a weaning trial was performed at the bedside using the protocol previously described [15]. If the patient tolerated the trial satisfactorily, the patient was taken to the operating room for removal of the cannulas. All cannula removals were performed after exposing femoral vessels. The femoral artery was repaired primarily with interrupted sutures of 5-0 Prolene (Ethicon, Somerville, NJ) or using a bovine pericardial patch. A pursestring suture of 4-0 or 5-0 Prolene was used to repair the femoral vein. A vacuum-assisted closure (Kinetic Concepts, Inc, San Antonio, TX) dressing was routinely placed after closure of the fascia.

Study Design

Patients were divided into two groups—group 1 with major vascular complications and group 2 without major vascular complications. Demographics between groups were compared using univariate and multivariate analysis including all variables to evaluate predisposing factors. The groups were also compared for outcomes. Mortality was the primary outcome, and the secondary outcome was the occurrence of any major complications during ECMO support. Kaplan-Meier survival curves were drawn for each group, and survival distributions were compared. Multivariate analysis was also performed to validate the result. Predisposing factors for mortality were evaluated by comparing 30-day survivors with nonsurvivors. After identifying significant predisposing factors for mortality, multivariate analysis was performed to determine the significance of vascular complications on survival.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation and compared with Student's t test. Categorical variables were evaluated by χ^2 test or Fisher's exact test as univariate analysis. Logistic regression analysis was used for multivariate analysis, and odds ratios were calculated. Survival distributions were compared with log rank test as univariate analysis and Cox proportional hazards model as multivariate analysis. Hazard ratio was also calculated. Probability values of less than 0.05 were deemed statistically significant. Statistical analysis was performed using the R statistical software package version 3.1.2 (R foundation, Vienna, Austria).

Results

There were 84 patients who met enrollment criteria. The ECMO survival rate (patients successfully weaned from ECMO) and the rate of survival to hospital discharge were 60% and 43%, respectively. Median length of survival was 32 days (95% confidence interval, 17 to 200). Seventeen patients (20%) had at least one episode of major vascular complication, including 10 patients (12%) with leg ischemia who progressed to compartment syndrome requiring prophylactic fasciotomy and 10 patients (12%) with significant bleeding or hematoma at the cannulation site that required surgical exploration. Three patients had both ischemic and hemorrhagic complications. None of the patients required limb amputation.

Predisposing Factors for Vascular Complications

Table 1 shows demographics of patients with and without vascular complications. Age and absence of a DPC were significantly different between the two groups by univariate analysis. However, by multivariate analysis, only the absence of a DPC was a significant predisposing factor (odds ratio, 18.7; $p = 0.03$; Table 2). The other factors including history or risk factors of peripheral vascular disease and severity of baseline condition were not significantly associated with vascular complications.

Outcome

Table 3 shows outcome of patients with and without vascular complication. Patients with vascular complication required significantly more procedures ($p = 0.01$), but there was no difference in the amount of transfusion required. Duration of ECMO support and hospital stay were not significantly different. Patients with a major vascular complication were more likely to experience disseminated intravascular coagulation.

Impact of Vascular Complications on Survival

UNIVARIATE ANALYSIS. The rates of survival to discharge were 18% and 49% in patients with and without a major vascular complication, respectively ($p = 0.02$). Figure 1 shows Kaplan-Meier curves of patients with and without vascular complication. Survival length of patients without vascular complication was significantly better than that of patients with vascular complication by univariate analysis ($p = 0.002$). Table 4 shows the hazard ratio for each vascular complication. Major ischemic complication (compartment syndrome) had the highest hazard ratio (3.03; $p = 0.003$), followed by major bleeding or hematoma that required surgical intervention (1.93; $p = 0.09$). The hazard ratio of bleeding or hematoma was lower than that of ischemia. The hazard ratio of major complications (ie, those that required surgical intervention) was higher than that of minor complications (ie, those treated conservatively). The influence of a DPC on survival was