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Venoarterial extracorporeal membrane oxygenation in acute myocardial infarction

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Introduction

Mortality and complications associated with acute myocardial infarction (AMI) have gradually decreased in the era of reperfusion therapy. However, the outcomes are still poor for AMI patients with severe complications.[1] The quest for further improvement of the use of active mechanical circulatory support (MCS) devices is rapidly evolving. Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is a form of heart-lung bypass that offers temporary mechanical support and simultaneous extracorporeal gas exchange, usually acting as a bridge to recovery. It has been widely used since 1972, after its introduction. Venoarterial extracorporeal membrane oxygenation provides cardiopulmonary support and is used to rescue patients with cardiopulmonary collapse. The use of VA-ECMO after AMI with severe complications is increasing. Recent studies have demonstrated a significant increase in survival using VA-ECMO in patients with AMI, and early VA-ECMO initiation yields better outcomes. This review article is aimed at evaluating the use of VA-ECMO in patients with AMI.[2]

Basic operating principle of venoarterial extracorporeal membrane oxygenation

The VA-ECMO consists of a venous inflow cannula, blood pump, membrane oxygenator, arterial outflow cannula, and heat exchanger. A venous inflow cannula allows blood to be drawn from the veins. The inflow cannula is often placed either peripherally, most commonly via the femoral vein, or centrally, in the vena cava or right atrium. The membrane oxygenator removes carbon dioxide and replenishes oxygen. After that, oxygenated blood is returned to the arterial via an arterial outflow cannula. The outflow cannula can be placed into the ascending aorta or the femoral artery. The effect of VA-ECMO is to displace the blood from the veins to the arteries. As a result, the right and left ventricular volumes could be reduced and the mean arterial pressure increased. Venoarterial extracorporeal membrane oxygenation results in a dramatic increase in cardiac output and mean arterial pressure and will usually achieve an increased flow rate of 4–6 L/min. Physiologically, systemic organ perfusion is improved.[3,4]

Venoarterial extracorporeal membrane oxygenation therapy in acute myocardial infarction

As a form of temporary MCS, VA-ECMO could provide cardiopulmonary support. In patients with AMI, VA-ECMO is suggested for temporary support with the potential for functional recovery. Previous studies suggest that VA-ECMO is a potential solution for AMI patients with severe complications, such as cardiogenic shock (CS), cardiac arrest, ventricular arrhythmia, ventricular septal rupture, and primary percutaneous coronary intervention (PCI).

Cardiogenic shock

Cardiogenic shock is the main cause of early mortality in AMI patients.[5,6] Retrospective studies highlighted the feasibility of using VA-ECMO in refractory CS. These studies found that critically ill patients had a higher in-hospital survival rate of more than 30%.[7] A meta-analysis of 13 studies reported that VA-ECMO was associated with a 13% increase in the 30-day survival rate compared with patients without ECMO.[8] A systematic review that included studies using VA-ECMO in patients with CS due to AMI suggests that the use of VA-ECMO treatment may provide survival benefits.[9] Venoarterial extracorporeal membrane oxygenation, as the major representative of MCS in CS, could give hemodynamic and respiratory support compared with other devices. European heart failure guidelines recommend ECMO treatment in refractory CS patients.

Cardiac arrest

Venoarterial extracorporeal membrane oxygenation is used during resuscitation from cardiac arrest. It is a powerful extracorporeal life support system, as long as it is initiated early. In patients who are unable to return from spontaneous circulation, extracorporeal cardiac pulmonary resuscitation uses VA-ECMO.[10] Extracorporeal cardiac pulmonary resuscitation with VA-ECMO in the patients improves both short- and long-term survival. The timing of VA-ECMO initiation should be within 21 minutes after cardiac arrest; otherwise, the prognosis is poor.[11] It should not be used in patients with unwitnessed cardiac arrest.

Ventricular arrhythmia

Refractory ventricular arrhythmia is a serious problem in AMI, with an extremely high mortality rate and limited effective treatment options.[12] Venoarterial extracorporeal membrane oxygenation has been used in AMI patients with refractory ventricular arrhythmia. A study enrolled 11 patients with refractory ventricular tachycardias (VT) using VA-ECMO from January 2002 to December 2004. ventricular tachycardias terminated rapidly after VA-ECMO use in all patients, and 9 patients had no recurrent VT or the need for internal

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cardiac defibrillator implantation when discharged.[13] Moreover, Yeh et al.[14] retrospectively analyzed a total of 69 patients with AMI and refractory ventricular arrhythmia who underwent VA-ECMO as rescue therapy and the bridge to revascularization from February 2001 to January 2013. These studies suggest that VA-ECMO is a feasible rescue therapy and bridge to revascularization for patients with refractory ventricular arrhythmia in AMI.[14]

Ventricular septal rupture

The incidence of postinfarct ventricular septal rupture (PIVSR) decreased because of early revascularization, but the morbidity and mortality of PIVSR are still high. Patients with PIVSR may require an MCS for definitive surgical repair; however, there are only a few published studies about the advanced MCS in PIVSR. Some studies, including case reports and small clinical series, suggested that VA-ECMO is a strategy to improve hemodynamic derangements and allows for delayed surgical repair.[15] However, the left ventricular afterload is increased, and this could increase the shunt fraction in PIVSR. The feasibility and safety of VA-ECMO in PIVSR need more studies to be confirmed.

Primary percutaneous coronary intervention

Revascularization of the culprit lesion forms the cornerstone of treatment. Venoarterial extracorporeal membrane oxygenation before primary percutaneous coronary intervention has shown some favorable results. Chung et al.[16] investigated the 30-day and long-term prognostic outcomes in patients with ST-segment elevation myocardial infarction (STEMI) complicated with profound CS undergoing early VA-ECMO–assisted primary PCI. They enrolled 65 consecutive STEMI patients between December 2005 and December 2014 and found that early ECMO-supported primary PCI in STEMI patients with profound CS was feasible as a life-saving strategy with acceptable 30-day and long-term prognostic outcomes.[16] A study consisting of 46 STEMI patients with CS who received ECMO and PCI from January 2005 to December 2014 found that VA-ECMO before PCI had significantly better 6-month survival, and the benefit persisted to the end of the 2-year follow-up. The data suggest that VA-ECMO before PCI improves both short- and long-term outcomes and is a reasonable and safe strategy in STEMI patients with CS.[17] Nishi et al.[18] identified 3815 AMI patients with CS who underwent primary PCI. They demonstrated that VA-ECMO combined with intra-aortic balloon pump had significantly lower mortality compared with VA-ECMO alone.[18]

Timing of venoarterial extracorporeal membrane oxygenation initiation

So far, the evidence about the timing of VA-ECMO initiation is still few. Several retrospective analyses indicated that the timing of VA-ECMO might influence outcomes. A multicenter study containing 362 refractory CS patients with VA-ECMO showed that the group of patients with early VA-ECMO initiation had lower all-cause mortality at 30 days. Early VA-ECMO initiation could also reduce ECMO weaning failure and all-cause mortality at 1 year.[19] Moreover, a single-center study containing 147 patients found the superiority of VA-ECMO initiation before revascularization.[20]

Complications

There has been a significant improvement in device technology and operator experience; however, the complication rates of ECMO are still high. The most frequent complications reported are bleeding, clotting, hemolysis, limb ischemia, infection, inadequate left ventricle unloading, acute kidney injury, and ECMO lung.

Contraindications

However, the benefits of ECMO in some situations are questionable. Patients with unwitnessed cardiac arrest, resuscitation effort lasting more than 60 minutes, aortic dissection, irreversible heart failure, or irreversible lung disease should not be given ECMO. Relative contraindications of ECMO include uncontrollable bleeding, severe coagulopathy, or contraindications to anticoagulation.

Conclusion

Management of AMI with severe complications remains challenging. Venoarterial extracorporeal membrane oxygenation is currently used as an MCS in critically ill patients. Venoarterial extracorporeal membrane oxygenation for AMI patients is a temporary support that provides advantages over standard care. Several retrospective analyses indicated that early initiation of VA-ECMO conferred survival benefits on a selected group of AMI patients. However, the evidence about the timing of VA-ECMO initiation is still limited, and further research is needed.

Conflict of interest statement

The author declares no conflict of interest.

Author contributions

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