EARLY PLACEMENT OF EXTRACORPOREAL MEMBRANE OXYGENATION: A SUITABLE ALTERNATIVE FOR PATIENTS WITH SEVERE CARDIOPULMONARY FAILURE

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CASE REPORTS

A 36-year-old male with known aortic insufficiency (AI) since adolescence and non-ischemic dilated cardiomyopathy presented with shortness o f breath and progression ro New York Heart S_{tage} III functional class. H e came fur evaluation and possible replacement o f his aortic valve.

Admission echocardiography {ECHO) showed left ventricular ejection fraction (LVEF) <20%, with a lefc ventricular end diastolic diameter o f 8.9 cm and severe AI on admission. The patient's congestive heart failure was managed on the floor with diuretics. A repeat E C H O while on dobutamine (4 mcg/kg/min) showed an ejection fraction (EF) o f 20-25% with severe AI. Cardiovascular surgery was consulted, and an deceive aortic valve replacement with a 27 mm ATS mechanical valve was completed.

The patient was excubated the next morning and went to che telemetry floor on the second post-op day (POD). The patient went into aerial fibrillation while on the floor, and rate control was achieved with amiodarone and digoxin.

O n P O D 11 the patient began having rapid aerial fibrillation with ventricular response and compromised blood pressure. Amiodarone boluses were given fur control. The patient subsequently became brad$_{y c}$ardic and hypotensive. Arrangements were made fur che patient co be transferred to the cardiovascular ICU, bur he went into cardiac arrest prior co transport. Cardiopulmonary resuscitation (CPR) was initiated, and advanced cardiac life support (ACLS) prococol began. Upon incubation, the code team became aware char the patient had aspirated gastric contents. ACLS protocol continued for a coca! o f 29 minutes. During chis time, the patient was given epinephrine and atropine and was defibrillated three times fur ventricular fibrillation. The surgeon performed bedside sub$_{x y}$phoid pericardia! window fur suspected cardiac tamponade, though minimal fluid was observed in the pericardia! cavity. With CPR in progress, the patient was taken to the operating room for furcher exploration.

Once in the O R, che patient remained in ventricular fibrillation with continuing CPR. Trans-esophageal echocardiography (TEE) revealed that the previously inserted aortic valve was in good position and functioning properly. Ventricular function was poor at <10%. A n 8 French Datascope intra-aortic balloon pump was inserted into the left femoral artery ro assist with LV function and reduce afterload. After counterpulsation began, the blood pressure continued co drop and became unresponsive to epinephrine and other inotropic boluses. The heart again began to fibrillate.

The chest cavity was then entered, internal cardiac massage began, and mulciple attempts at defibrillation were made. Emergency cannulation was performed, and the team prepared for cardiopulmonary bypass. Ventricular fibrillation continued despite pharmacologic management and several more attempts at defibrillation. The patient was then crossclamped, and a one-licer cardioplegic solution o f 4:1 was administered. Despite all o f these measures, right ventricular fibrillation continued. The crossclamp was released, and several more attempts at defibrillation proved ineffective. The aorta was again cross-damped, and one liter o f 1:1 cardioplegia was given to obtain complete cardiac arrest. The heart was allowed co rest for approximately 40 minutes, and, after removing the crossclamp, the patient spontaneously recovered a wide complex rhythm with pulse-generating flow. At this rime EF by T E E continued co be low, estimated at 15%, and transplant surgery was consulted in che O R. A left ventricular assist device was considered to increase perfusion; however, given the large aspiration during the code and difficul$_{t y}$ in oxygenating the patient during surgery, the team ultimately chose extracorporeal membrane oxygenation (ECMO).

Cannulation sites for the E C M O were placed in the right atrium using a 34/46 Fr with return flow to che aorta using a 21 Fr Argyle. A Carmeda® Affini$_{t y}$® N T O$_{x y}$genaor with a non-leaching, heparin-coated circuit was used with a BioMedicus® pump. The Terumo_ CDJT^{M}, 500 was also used to continually assess blood-gas parameters.

Urine output was minimal while on bypass, so a Mahurkar® dialysis catheter was placed in anticipation o f acute renal fu.ilure and the need for continuous veno-venous hemodialysis (CVVHD).

ICU COURSE

The patient was admitted to the ICU with an open chest, ECMO and IABP. His blood pressure was 68/45 with an augmented diastolic o f 81, mean arterial pressure o f 69, and central venous pressure of 13. He was admitted on vasopressor and inocropic support via norepinephrine (16 mcg/kg/min and 4 mcg/min epinephrine, respectively); E C M O speed was 2590 rpm with a flow of 4 - 4.4L/min. A ventilator for assist-control ventilation was set at 20 breaths per minute, with FiO2 of 60%, tidal volume of 700 ml, and positive end-expiratory pressure of 5 cm H2O.

The patient was subsequently placed

on our sedation protocol and then paralyzed. Continuous fentanyl and lorazepam infusions were titrated for a bispectral index scale of 40-60, and the patiem was paralyzed with NIMBEX® infusion co keep train-of-four twitches to two out of four.

Within cwo hours, the FiO2 was weaned ro 40% fur a PO2 of 160 mm Hg.

CWHD was started upon ICU arrival for volume removal. The post-op crearinine was 1.9 mg/di and blood urea nitrogen was 36 mg/di (from 1.1/31 mg/di at pre-op). The patient was still making urine at the rate of 100-130 ml/hr prior co start of CWHD bur decreased to 15-30 ml/hr upon initiation.

The epinephrine was kept at 3 mcg/min umil the chest was closed, while norepinephrine was weaned to a mean arterial pressure of >65 mm Hg.

Heparin IV was started 9.5 hours postoperatively and titrated for an activated clotting time of 180-200 seconds. The platelet count was 313,000 preoperatively, fell to 115,000 postoperatively, and continued co fall to 35,000 on POD 2. A heparin antibody screen was sent. On POD 3, the ECMO was explanted and the heparin drip was stopped. That afternoon the results came back positive for heparin antibody though the titer was relatively low at 0 .793. No further heparin was used.

The IABP was removed on POD 4. Doburamine 3 mcg/kg/min remained, with cardiac index of 2.5 L/min/m2. A feeding rube was inserted and a renal tube feeding formula was started. CWHD was discontinued on POD 5 (creatinine 2.1 mb/dl, BUN 41 mg/di). Anticoagulation for the mechanical valve was started on POD 6, as was hemodialysis. The ventilator was weaned and the patient was exrubated on POD 7. The patient started physical therapy on POD 8, could sit on the side of the bed by POD 10, and was standing on POD 12. An automatic implantable cardiovercer defibrillator was placed on POD 13. The patient could walk 15 feet on POD 17 and increased co 50 feet on POD 18. By POD 21, renal function had improved. The patiem began making urine, was transferred co the floor, and discharged on POD 30. The patient returned once for drainage of pleural effusion buc was discharged the same day.

COMMENT

Our patient starred with low cardiac output syndrome (EF 20%). He underwent aortic valve replacement, atrial fibrillation, cardiac arrest, aspiration pneumonitis, and placement of IABP, ECMO and CVVHD.

Approximately 1% of all paciencs undergoing cardiac surgery require prolonged postoperative circulatory support due co refractory cardiac and/or respiratory dysfunction.[2,3] These patients present a therapeutic challenge because of their high-risk profile and their inability co be managed with standard medical therapy. Various temporary circulatory support devices such as centrifugal pumps or pneumatic pulsatile pumps are currently available for such patients. Extracorporeal membrane oxygenation is another treatment modality for temporary bridging in the critical early postoperative period.

Low cardiac output syndrome is a devastating condition. Given the critical condition of our patient, our treatment preference was co use ECMO for ventricular and respiratory support. Several studies have demonstrated mortality rates of 50-70% among patients requiring ECMO support. Predictors of increased mortality were old age, evidence of organ system dysfunction, history of previous cardiac surgery, extensive aortic operations, neurologic events, and not using an IABP.[1,3,4,7,9]

Interestingly, patients undergoing combined CABG and aortic valve replacement and requiring ECMO have a mortality rate of 95%, which is worse than that of other surgeries for either procedure alone.[6]

Cannulation for ECMO support is now mostly performed on the ascending aorta and right atrium, maintaining the cardiopulmonary bypass cannulas or placing new cannulas while the chest is open. This helps to avoid limb ischemia as seen with femoral cannulations. The chest remains routinely open with sterile draping to prevent functional camponade.

The use of an IABP to maintain pulsatility during ECMO support is not uniformly agreed upon in literature. However, patients with IABP had a significantly higher survival rate. Some centers recommend concomitant use of IABP coumerpulsation during ECMO support to increase pulsatilicy, improve coronary perfusion, and decrease the ventricular afcerload.

Bleeding cominues to be a major complication of ECMO supporr.[5,10,11] The use of heparin-coated circuits, lower doses of heparin, antifibrinolytic agents such as aminocaproic acid, and aprotinin have been recommended but received mixed results.[2,12,13] As a moderate amount of anticoagulation will always be required, some clinicians think that less traumatic pumps with improved hemodynamics and silicone membrane oxygenator may decrease mechanical stress and damage to blood components to further reduce these complications.

Precise monitoring and adjustment of gas exchange is very important during ECMO support. Ir is well documenced that lower serum CO2 values lead to pulmonary vasodilatation and cerebral vasoconstriction. Allowing some lung perfusion during ECMO may prevent reperfusion pulmonary edema. Gleason and associates recommend subcle adjustments of CO2 over a period of at least 24 hours to prevent reactive cerebral hyperemia and subsequent risk of cerebral hemorrhage during anticoagulation.14 Mechanical ventilation with a FiO2 <50% is recommended during ECMO support, and positive end-expiratory pressure of 5 co 8 cm of H2O can be used to prevent atelecrasis. Peak ventilation pressure should not exceed 30 cm of H2O co prevent barotraumas.15 Nitric oxide should be used in the ventilation circuit when there is evidence of right ventricular dysfunction.16

Due co our patient's acute renal failure, we performed CVVHD during ECMO support to prevent volume overload from multiple blood produce transfusions and maintain adequate intravascular volume.

The weaning process in some patients can be very challenging.3 Most ECMO weaning protocols involve rapid reduction of flow from 2 L/min/m- to zero in only a few minutes while ventricular function is observed through an open thorax or under TEE.8·17 In our patient, we found that slow weaning was advantageous due to low LVEF. We adapted slow weaning by decreasing ECMO flows slowly down to 1 L/min over a 24-36 hour period regardless of body surface area.

Management of ECMO in the ICU requires a well-trained team, a significant amount of planning, and coordination among different services and organizations. At the Methodist DeBakey Heart Center CVICU, we have a dedicated team of in-house intensiviscs, physician assistants (PAs), nurse practitioners (NPs) and perfusionists who keep watch over patients around the clock. The ECMO circuit is checked regularly and adjusted as required by an experienced perfusionist.

Before caring for these types of patients, nurses should undergo special training in ECMO management while intensivists and an experienced surgeon should decide together when mediastinal bleeding requires surgical intervention. Evaluation of cardiac function should be done daily co determine when ECMO weaning is possible. Despite a significant amount of work involved for all ream members, we believe that ECMO is a feasible method of supporting patients with severe cardiorespiratory failure.

SUMMARY

Our patient presented with severeaorric stenosis and low LVEF and underwent heart surgery for aortic replacement. He lacer developed atrial fibrillation and cardiac arrest. Under the circumstances of cardiorespiracory failure, we chose to place our patient on ECMO support. We made that decision in a timely manner and transferred the patient to the CVICU, where an organized team coordinated his care with great vigilance. Constant monitoring of ECMO, hemodynamics, arterial blood gases, fluid balance on CVVHD, anticoagulation, infection control, sedation analgesia and many minor details allowed us co wean our patient from ECMO successfully and evencually discharge him to home.

We believe that ECMO can be used for temporary, complete circulatory support while awaiting myocardial recovery or determining suitability for heart transplantation. Overall, one-half of ECMO patients can be weaned successfully and almost one-third can be discharged from hospitals. With proper organization and implementation, ECMO can be a suitable alternative for patients with severe cardiopulmonary failure in post-cardiac surgery patients.

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