We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800
Open access books available

122,000
International authors and editors

135M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS BOOK CITATION INDEX INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

7

Role of Percutaneous Cardiopulmonary Support (PCPS) in Patients with Unstable Hemodynamics During the Peri-Coronary-Intervention Period

Ho-Ki Min[1] and Young Tak Lee[2]
[1]*Department of Thoracic and Cardiovascular Surgery, Haeundae Paik Hospital, Inje University College of Medicine, Busan*
[2]*Department of Thoracic and Cardiovascular Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul*
Korea

1. Introduction

Coronary artery disease remains the principal cause of death in developed countries, with acute coronary syndrome (ACS) contributing greatly to cardiovascular morbidity and mortality. Optimal revascularization therapy in these patients is of major importance and remains the basis for favorable outcomes. The intervention-based strategy plays a major role in the management of acute-phase patients because of the cardiovascular benefits demonstrated in numerous studies. In serious cases, ACS can be encountered with life threatening episodes such as cardiogenic shock or cardiac arrest in the peri-intervention period. Compared with the intra-aortic balloon pump (IABP), percutaneous cardiopulmonary support (PCPS) can maintain hemodynamic stability in the abscence of an intrinsic cardiac rhythm or effective cardiac output and can provide excellent mechanical circulatory support in these urgent or emergent situations because it can be implanted and stabilized promptly in many different hospital locations, including the cardiac catheterization laboratory, and if necessary, in the emergency room or intensive care unit. Some reports use PCPS to rescue ACS patients with cardiopulmonary failure (Sung, 2006; Grambow, 1994). Herein, we present our experience with the use of PCPS for initial stabilization in patients with unstable hemodynamics before or after coronary intervention and discuss some of the pertinent issues related to this topic.

2. Extracorporeal membrane oxygenation

2.1 Introduction

Extra corporeal membrane oxygenation (ECMO) techniques became available40 years ago. In 1972, the first veno-arterial ECMO system for humans was used in a patient with acute respiratory distress syndrome (Hill, 1972). The first successful application of neonatal ECMO was performed by Bartlett in 1976 (Bartlett, 1976), and the concept of veno-venous ECMO to eliminate CO_2 was established by Kolobow in 1980 (Kolobow,

1980). In the last decade, enormous advances have been made and ECMO has become more reliable with improved equipment and increased experience, which is reflected in the improved results. ECMO is used for the management of life threatening pulmonary or cardiac failure (or both), when no other form of treatment has been or is likely to be successful. ECMO is generally used as temporary support while awaiting recovery of organs.

ECMO is essentially a modification of the cardiopulmonary bypass circuit, which is used routinely in cardiac surgery. Blood is drained from the venous system peripherally or centrally, oxygenated with carbon dioxide extracted, then returned back to the arterial system peripherally or centrally.

Although ECMO remains a short-term support device, the use of such a circuit for extended periods (days to weeks) has required some modifications. Specially, the circuit is smaller than a standard cardiopulmonary bypass circuit, transportable, and closed to the atmosphere. The cannulae are also specifically designed for ECMO. The duration of support with ECMO has greatly increased with improving oxygenators and medical management, and whereas support was previously on the order of days, patients can now be maintained on ECMO for weeks. In most patients the duration of support required is approximately 1 week. Most commonly, ECMO is used in an emergency or urgent situation after failure of other treatment modalities.

2.2 Indications for ECMO

ECMO is indicated for all the reversible pulmonary or cardiac failures (or both) refractory to conventional therapy. ECMO is usually used for initial stabilization and temporary support while awaiting recovery of organs. However, physicians should keep in mind that the results of ECMO support are consistently related to the indication for institution of such therapy.

With respect to cardiac failure, ECMO has been used successfully to resuscitate patients with cardiac arrest or cardiogenic shock due to acute coronary syndrome, post-cardiotomy cardiac failure, transplant rejection, intractable dysrhythmia, ruptured coronary artery graft, pericardial tamponade, cardiac trauma, sepsis, and myocarditis. ECMO has also been effective in patients with secondary cardiac failure due to respiratory insufficiency, hypothermic arrest from cold-water submersion, and drug overdose. The indications for ECMO in cardiopulmonary resuscitation are summarized in Table 1.

In making the decision to use ECMO, several considerations must be weighed. Most importantly, physicians must consider the possibility of cardiac recovery. If recovery is not expected, consideration must be given to patient eligibility for heart transplantation, other mechanical assist devices to bridge the patient to transplantation, or a definitive mechanical assist device to be inserted as destination therapy. Moreover, patient selection is the most important prognostic indicator. Although some relative contraindications have been proposed, there are few generally accepted absolute contraindications to ECMO. Unwitnessed cardiac arrest, aortic dissection, and terminal illness are considered to be the most important contraindications. The mortality rate after an unwitnessed cardiac arrest approaches 100% and has not changed with the use of ECMO. Early and effective resuscitation can allow for neurologically-intact survivors, but this is less likely to occur in an unwitnessed arrest. Aortic insufficiency is another relative contraindication, particularly if severe. In such situations, aortic valve replacement should be considered. Lesser degrees of aortic insufficiency may be managed with a left ventricular vent. Failure to insert a vent

leads to ventricular distension, compromised subendocardial blood flow with an impact on recovery, and the ability to wean from ECMO.

Renal failure, hepatic failure, and significant neurologic disease are relative contraindications to ECMO, depending on the existence of other therapeutic options and the degree of dysfunction (Meurs, 2005).

With respect to respiratory failure, the most common indication is due to adult respiratory distress syndrome (ARDS), pneumonia, trauma, or primary graft failure following lung transplantation. ECMO is also used for neonatal and pediatric respiratory support. The use of ECMO in premature neonates is the mainstay of treatment for immature lungs and insufficient surfactant.

More recently, indications for ECMO have been expanded to pro-procedural supports, such as major airway intervention/surgery and cardiac intervention, including high-risk coronary angioplasty or arrhythmia ablation (Table 1). In a small and retrospective study, Grambow et al. proposed that patients requiring coronary revascularization by angioplasty who have severe left ventricular dysfunction or target vessels supplying greater than 50% of the myocardium are candidates for elective ECMO (Grambow, 1994).

Indications
Resuscitation
Cardiac arrest
Cardiogenic shock
Cardiac trauma
Respiratory insufficiency
Status asthmaticus
Smoke inhalation
Drug overdose
Pulmonary edema
Massive pulmonary embolism
Hypothermia
Procedural support
Angioplasty
Arrhythmia ablation
Pulmonary embolectomy
Coronary artery bypass grafting
Cerebral arteriovenous malformation resection
Donor heart preservation
Abdominal aortic graft replacement
Tracheal reconstruction
Ventricular assist device placement

Table 1. Indications for ECMO

2.3 Mode of ECMO

ECMO can be inserted in a veno-venous (VV) mode, which provides oxygenation and CO_2 removal, and thus is used for pulmonary failure not responding to mechanical ventilation, or can be used in a veno-arterial (VA) mode providing sufficient end-organ perfusion and gas exchange. VA ECMO can be instituted peripherally or centrally.

VV ECMO refers to blood being drained from the venous system and returned to the venous system. This mode only provides respiratory support and is achieved by peripheral cannulation, usually via the femoral or jugular veins. VA ECMO refers to blood being drained from the venous system and returned to the arterial system. The VA ECMO mode provides cardiac and respiratory support, and can be divided into two groups according to vascular access peripherally or centrally.

When using 'central' cannulation, in which the ascending aorta and right atrium are directly cannulated, this is referred to as 'central' ECMO. Central ECMO allows better flow because of better drainage from the right atrium with a bigger cannula and is usually required in patients with a larger body surface area (> 2.0 m^2). The other advantage of central ECMO is that the flow directly from the outflow cannula into the aorta provides antegrade flow to the arch vessels, coronary arteries, and the rest of the body (Fig. 1). However, central ECMO also has its drawbacks. Insertion of central ECMO requires a median sternotomy to allow the cannulation. This is a time-consuming procedure and increases the risk of bleeding from the sternum and also of infection. In contrast to central ECMO, it can be achieved by peripheral vascular access and is called 'peripheral' ECMO or percutaneous cardiopulmonary support (PCPS), in which insertion is more prompt via a bed-side procedure than central ECMO because there is no need for a sternotomy and the risk of

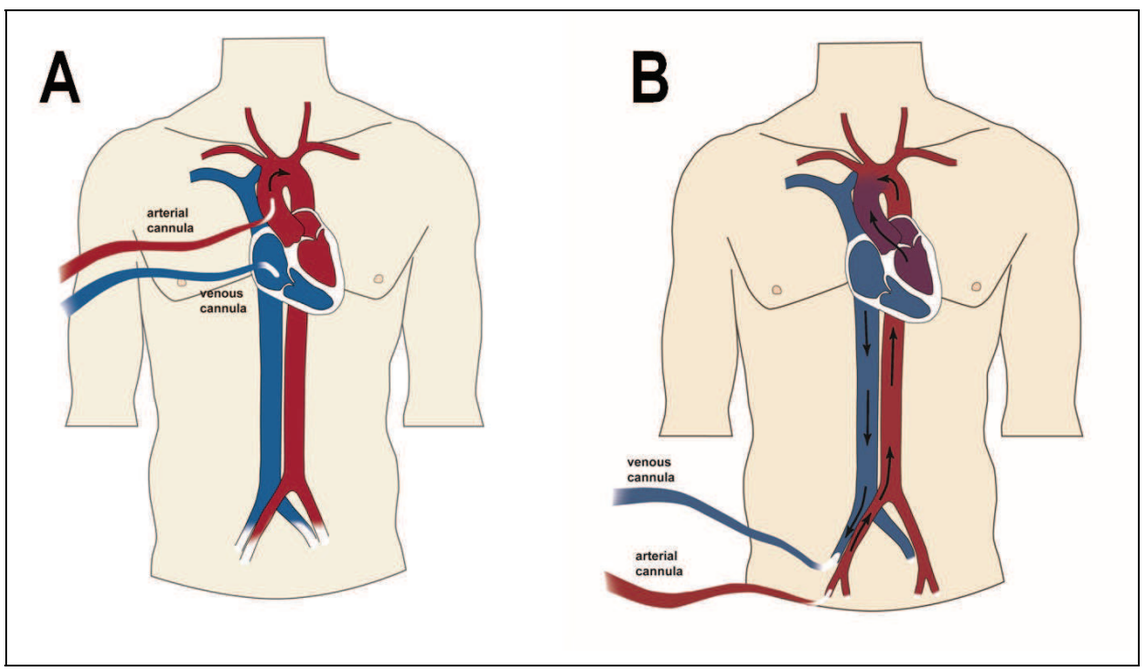


Fig. 1. Mode of ECMO. Panel A represents central ECMO and panel B represents peripheral ECMO.

bleeding is decreased. However, the retrograde aortic flow provided by peripheral ECMO from the femoral artery leads to admixing in the arch (two circulation syndrome). For this reason, monitoring of oxygenation from a right radial arterial line would be prudent. Mechanical ventilation must be continued during ECMO support to maintain oxygen saturation of blood ejected from the left ventricle to at least above 90%. In patients on PCPS, single access cannulae may not be sufficient to achieve satisfactory perfusion and gas exchange. In these patients a second access cannula is inserted via the right internal jugular vein ,so sufficient flow can be achieved.

2.4 Maintenance and Weaning of ECMO

The basic function of VA ECMO in supplying mechanical circulatory support is to drain blood from the venous circulation, oxygenate the blood, and then return the blood to the arterial circulation at physiologic perfusion pressures. Although ECMO efficiently unload the right ventricle, ECMO is not efficient in unloading the left ventricle. Indeed, ECMO increases left ventricular afterload, thus negatively affecting myocardial recovery, even though left ventricular preload is significantly reduced by the diminished return from the lungs. For this reason, attempts to improve left ventricular contractility, reducing left ventricular distension, left ventricular afterload, and clot formation are of utmost importance. Such measures should include inotropic support and may include intra-aortic balloon pumping (IABP), which can decrease left ventricular afterload and therefore reducing wall stress, especially during the critical initial period. Other options include inserting a left ventricular vent to empty the ventricle connecting this line into the venous line of the ECMO circuit, to place an additional drainage catheter in the left atrium that can be placed via the percutaneous route (Aiyagari, 2006), or to perform an atrial septostomy to decompress the left heart (Koenig, 1993).

ECMO flow can be volume-dependent and will drop with hypovolemia, cannula malposition, pneumothorax, and pericardial tamponade, and usually manifests as 'kicking' or 'chatter' of the venous tubing as well as a drop in output. Management includes a volume challenge, and exclusion of intra-abdominal distension or compartment syndrome, cardiac tamponade, or pneumothorax. If a volume challenge does not work, a slight reduction in flow may be helpful or there may be a need to insert another venous cannula. Further, centrifugal pumps in contrast to roller pumps are afterload-dependent, and therefore hypertension is another variable that can reduce flow and should be avoided.

From a respiratory point of view, hypoxia is treated by increasing the flow rate and FiO_2 of the ECMO circuit, not by altering the FiO_2 and PEEP on the ventilator. Attempts to support and rest the lung should be made to wean the FiO_2 on the ventilator and maintain a PEEP level of 8-15 cmH_2O. A protective lung ventilation strategy with low plateau pressures and low tidal volumes should be attempted as well as low respiratory rates, unless attempting to wean off the ECMO circuit. PCO_2 control should be via the ECMO fresh gas flow to the oxygenator, not by altering the respiratory rate on the ventilator.

From a cardiac point of view, the aim should be to minimize the use of inotropes, and thus rest the heart. However, a low-dose inotrope infusion is often maintained to ensure some contractility and adequate emptying of the left ventricle. It is also important to ensure the patient is not hypovolemic.

There are no standardized methods or techniques by which to wean from ECMO. With respect to VV ECMO, weaning and discontinuation are considered when there is evidence

of substantial improvement in the underlying disease process and cardiopulmonary function based on radiographs, laboratory parameters, hemodynamic parameters, and gas exchange. While monitoring these parameters, flow through the circuit can gradually be reduced. When a reduction in flow of 75% can be achieved without changes in cardiopulmonary status, membrane gas flow can be stopped. If the patient tolerates those challenges for 12 hours with adequate gas exchange and hemodynamic parameters, VV ECMO can be removed (Gravlee, 2008).

With respect to VA ECMO, weaning and discontinuation are considered when there is evidence of cardiac recovery, including increased blood pressure, return of pulsatility or increased pulsatility on the arterial pressure waveform, and falling central venous and/or pulmonary pressures. Weaning is performed under echocardiographic guidance with regular arterial blood gas and lactate measurements. ECMO flow rates are slowly weaned, while inotropes and ventilator support are adjusted after echocardiography confirms adequate ventricular filling and ejection. Blood gases and serum lactate levels are then assayed to confirm adequate gas exchange and oxygen delivery, respectively. Until a reduction in flow of 75% can be achieved or a flow rate is below 1 – 1.5 liter/min without changes in cardiopulmonary status over 12 – 24 hours, weaning can proceed. If the patient tolerates those challenges for 12 hours with adequate parameters, VA ECMO can be removed.

2.5 Complications of ECMO

Bleeding and hemolysis, multi-organ failure, infection, and equipment failure are the common complications that contribute to morbidity and mortality associated with ECMO in adults. The complications that have been reported to the Extracorporeal Life Support Organization (ELSO) Registry in adult patients treated with ECMO are listed in Table 2, and data on complications and events reported in the ELSO Registry are shown in Table 3 (Meurs, 2005).

The most common complication associated with the use of ECMO is bleeding from cannulation sites, with typical rates ranging 4-14% (Kurusz, 2002). Excessive bleeding is caused by multiple factors. Hepatic congestion and failure, malnutrition, multiple cannulation sites, low-dose anticoagulation with heparin, decreased platelet function, activation of the coagulation cascade secondary to hemolysis, and hyperfibrinolysis from contact with prosthetic surfaces all may contribute to increased bleeding. The use of heparin-coated circuits in addition to the antifibrolytics and vitamin K therapies has contributed to lower bleeding rates. Vena cava tears or rupture with retroperitoneal bleeding, and arterial or aortic injury including dissection and perforation that required surgical exploration and reconstruction have occurred. Other non-cannula-related bleeding complications include pulmonary and gastrointestinal hemorrhage.

Ischemic injury to the brain, kidneys, liver, and other end organs has been attributed to prolonged resuscitation and as well as inadequate pump flow. Recovery from a moderate hypoxic-ischemic insult is possible for most organs; however, neurologic recovery is frequently limited. Emergency ECMO and early coronary perfusion using percutaneous transluminal coronary angioplasty (PTCA) can result in good myocardial recovery. By using mild hypothermia in conjunction with ECMO during PTCA, a 2- to 5-fold increase in the rate of good neurologic recovery was achieved in a series reported by Nagao et al (Nagao, 2000).

Overall infection rates in temporary mechanical circulatory support have been reported to be as high as 30-40% (Patel, 2003). Immobilization, poor nutritional status, and indwelling

catheters and tubes are all likely to contribute to the high incidence of infection. Although infrequent now, severe lower limb ischemia leading to amputation has occurred with femoral artery cannulation. Perfusion in the cannulated leg should be monitored closely for evidence of ischemia. Placement of a smaller, additional femoral artery cannula to perfuse the lower limb distal to the ECMO cannula has reduced the risk of this complication. Limb complications have been reported to occur in as many as 25% of patients prior to the use of the distal cannulation technique (Patel, 2003; Schwarz, 2003).

Complications
Cannula related
Perforated femoral or iliac artery
Retroperitoneal bleed
Aortic dissection
Limb ischemia
Poor venous drainage
Failure to cannulate
Hemorrhagic
Bleeding at cannulation site
Bleeding at surgical site
Pulmonary hemorrhage
Gastrointestinal hemorrhage
Cerebrovascular accident
Thromboembolic
Limb ischemia
Pulmonary infarction
Cerebrovascular accident
Insufficient perfusion
Ischemic brain injury
Renal failure
Hepatic failure
Multi-systemic organ dysfunction
Technical
Equipment failure
Hemolysis
Infection
Insufficient ventricular unloading
Ventricular dysfunction and pulmonary edema

Table 2. Complications associated with ECMO

Complications	Pediatric		Adult	
	n	%	n	%
Mechanical				
Air in circuit	21	3.5	4	2.2
Cannula problems	68	11.5	13	7.2
Clots: Bladder	31	5.1		
Bridge	19	3.2	2	1.1
Hemofilter	28	4.6	7	3.9
Oxygenator	60	10	13	7.2
Other	50	8.3	10	5.5
Cracks in pigtail connectors	5	0.8	5	2.8
Heat exchanger malfunction	1	0.2		
Other tubing rupture	4	0.7	2	1.1
Oxygenator failure	52	8.6	39	21.6
Pump malfunction	6	1	1	0.6
Raceway rupture	3	0.5		
Metabolic				
Glucose < 40 mg/dl	14	2.3	1	0.6
Glucose > 240 mg/dl	83	13.8	75	41.4
Hyperbilirubinemia (> 2 direct or > 15 total)	30	5	14	7.7
pH < 7.20	77	12.8	41	22.7
pH > 7.60	25	4.2	14	7.7
Neurologic				
Brain death clinically determined	70	11.6	27	14.9
CNS hemorrhage by US/CT	42	7	1	0.6
CNS infarction by US/CT	43	7.1	24	13.3
Seizures				
Clinically determined	69	11.4	7	3.9
EEG determined	32	5.3	1	0.6
Pulmonary				
Pneumothorax requiring treatment	15	2.5	7	3.9
Pulmonary hemorrhage	55	9.1	11	6.1
Renal				
CAVHD required	41	6.8	39	21.6
Hemofiltration required	170	28.2	22	12.1
Cardiovascular				
Cardiac arrhythmia	110	17.3	44	24.3
CPR required	48	8	12	6.6
Hypertension requiring vasodilators	74	12.3	13	7.2
Inotropes on ECMO	414	68.7	152	84
Myocardial stun by echocardiography	38	6.3	4	2.2
PDA: Bidirectional	2	0.3		
L->R	2	0.3		
R->L	2	0.3		
Tamponade: Blood	35	5.8	21	11.6

Complications	Pediatric		Adult	
	n	%	n	%
Serous	2	0.3		
Hemorrhagic				
Cannulation site bleeding	105	17.4	40	22.1
Disseminated intravascular coagulation	37	6.1	5	2.8
GI hemorrhage	19	3.2	7	3.9
Hemolysis (Hemoglobin > 50 mg/dl)	75	12.4	28	15.5
Surgical site bleeding	101	16.8	53	29.3
Infections				
Culture-proven infection	54	9	28	15.5
White blood cell > 1,500	6	1		

CAVHD = continuous arteriovenous hemodialysis, CNS = central nervous system, CPR = cardiopulmonary resuscitation, CT = computed tomography, EEG = electroencephalogram, GI = gastrointestinal, L->R = left to right shunt, R->L = right to left shunt, US = ultrasound.
Table 3. Complications reported to the ELSO Registry (1994 – July 2005)

In addition, intracardiac thrombus may form within a poorly contracting, nonejecting left ventricle or atrium because little blood reaches the left atrium with good right atrial drainage (Cohn, 2008). Because intracardiac thrombus may induce systemic embolism, thus serial echocardiogram should be followed up for early detection and ECMO patients do require low level heparinization to prevent this complication.

2.6 Outcomes of ECMO

The results of ECMO support are consistently related to the indication for institution of such therapy.

With respect to VV ECMO, Bartlett et al at the University of Michigan were reviewed in 1995 and reported that VV ECMO for respiratory failure provided survival to discharge in 88% of 586 cases of respiratory failure in neonates, 70% for 132 cases of respiratory failure in children and 56% for 146 cases of respiratory failure in adults (Bartlett, 1997). In 2008, the ELSO revealed similar results; specially 972 cases of ECMO support for respiratory failure were reported, of which 53% survived to discharge in the adult population (>18 years). Unfortunately, good quality randomized controlled trials of ECMO outcomes in the adult population are lacking. The incomplete CESAR (Conventional Ventilation or ECMO for Severe Adult Respiratory Failure) was a national randomized controlled trial in the United Kingdom funded by the National Health Service and the Health Technology Assessment Agency; preliminary results were recently released at the 37th Society of Critical Care Medicine Congress in Honolulu in February 2008. The hypothesis was that ECMO will improve survival without severe disability by 6 months post-randomization for patients with severe, but potentially reversible respiratory failure. Severe disability was defined as confined to bed and unable to dress or wash oneself. Suitable patients can be entered from any of the 96 participating hospitals and were randomized to either transfer to Glenfiele hospital for consideration of ECMO or continued conventional management. The conventional group underwent standard clinical practice in the UK. Recruitment was conducted from July 2001 to August 2006. Of the 90 patients assigned to receive ECMO, 22 did not receive ECMO, most often because they improved without it. Patient characteristics

were well matched between groups. Of the patients randomly assigned to receive ECMO, 57 of 90 met the primary endpoint of survival or absence of severe disability at 6 months compared with 41 of 87 patients in the conventional ventilation group. This translated to a relative risk in favor of the ECMO group of 0.69 (95% confidence interval, 0.05–0.97; P = 0.03). A significant number of patients had failure of more than 3 organs in both groups (28 in the ECMO group and 27 in the conventional group). The benefit of ECMO was evident, regardless of age, duration of high-pressure ventilation, primary diagnosis at trial entry, and number of organs failing (Peek, 2006; Hitt, 2008).

With respect to VA ECMO, Bartlett et al at the University of Michigan were reviewed in 1995. Their experience with cardiac failure is somewhat smaller with a 33% survival rate in 31 adult patients and 48% survival in 105 pediatric patients (Bartlett, 1997). In 2008, ELSO revealed similar results that 474 patients were supported for cardiac failure of which only 33% survived to discharge. In addition, numerous studies have reported various results according to the disease diagnosis. The data reported to the ELSO registry has shown that myocarditis is associated with a better survival than other diagnosis, with almost three-fifths being successfully weaned from ECMO. Similarly, Acker reported that twenty seven (73.0%) of a group of 37 patients could be weaned from ECMO and 26 patients (70.3%) were discharged from the hospital (Acker, 2001). In this subgroup of patients, ECMO may be used as a bridge to recovery, bridge, or transplantation. Cardiac arrest and shock are the most common indications for ECMO in adults and the benefits of ECMO for cardiac arrest in adults were shown recently (Chen, 2008). Early implementation of ECMO can improve the survival rate to 30-40%, as described in multiple published series and the ELSO registry (Sung, 2006; Meurs, 2005). For acute myocardial infarction, cardiogenic shock is the leading cause of death in hospitalized adults. In these patients, ECMO alone has a limited effect on outcome, but when combined with emergency coronary revascularization by angioplasty, it may improve survival. Also, the concomitant use of an intra-aortic balloon pump with ECMO improves survival in patients with cardiogenic shock. The role of ECMO to provide post-cardiotomy support with severe cardiopulmonary dysfunction after cardiac surgery is well established. Mechanical circulatory support may be required in the post-operative period, either due to the inability to separate from cardiopulmonary bypass, or a progressive low cardiac output syndrome due to a number of factors, such as ventricular dysfunction, pulmonary hypertension, or intractable arrhythmias. The incidence of post-cardiotomy myocardial failure is 2-6% in adult cardiac surgical patients. Rousou et al. reported that 56% of a group of 16 patients survived ongoing post-operative ventricular fibrillation or electromechanical dissociation when ECMO was employed (Rousou, 1994). Similarly, 77% of a group of 13 patients described by Kawahito et al. successfully weaned off ECMO after circulatory collapse from ventricular fibrillation or electromechanical dissociation that was refractory to inotropic agents, IABP, and cardiopulmonary resuscitation (Kawahito, 1994). ECMO has been utilized in the cardiac catheterization laboratory for resuscitation during sudden cardiovascular collapse to provide temporary support for interventional procedures. In a small, retrospective study by Grambow et al., rapid initiation of ECMO (within 20 minutes) resulted in the rescue of patients in cardiogenic shock, but all patients who experienced cardiac arrest died despite ECMO and further interventions. Of those in shocks who were initially salvaged with ECMO, approximately 50% survived for 24 hours but only 25% to hospital discharge. Mortality after 24 hours was attributed to sepsis, multi-organ failure, or congestive heart failure (Grambow, 1994).

3. Our experiences and results

3.1 Study patients

Between May 2005 and December 2010, 402 ECMOs were implanted at the Samsung Medical Center and a retrospective review was performed. Of them, 79 patients were treated with PCPS during peri-intervention period for either refractory cardiac arrest or cardiogenic shock. Patients were considered to have refractory cardiac arrest only if aggressive attempts at resuscitation were unsuccessful in establishing a stable cardiac rhythm. Patients were placed on PCPS for cardiogenic shock if hypotension and peripheral hypoperfusion persist despite aggressive fluid replacement and inotropic support.

3.2 Technique of PCPS

Both femoral areas were draped under sterile conditions if PCPS was indicated. After the intravenous injection of 10 mg/kg of heparin, both the femoral artery and femoral vein were cannulated percutaneously using the Seldinger technique. In some patients, femoral cannulation was completed after an inguinal incision because of difficulties with the percutaneous cannulation. If in the cardiac catheterization, fluoroscopy may be used as well to facilitate guide-wire and cannulae placement. The PCPS could be inserted into all patients for whom it was intended. According to the patient's size, 14 to 21 Fr percutaneous femoral arterial cannulae (DLP; Medtronic Inc, Minneapolis, MN or RMI; Edwards Lifesciences, Irvine, CA) and 17 to 28 Fr percutaneous femoral long venous cannulae (DLP; Medtronic Inc, or RMI; Edwards Lifesciences) were used. In some patients, distal femoral arterial perfusion was performed using a central line catheter (Arrow International, Reading, PA) after distal femoral artery puncture to avoid ischemia of the distal lower leg. The PCPS was then started using the Capiox emergency bypass system (EBS; Terumo Inc, Tokyo, Japan), which comprises a centrifugal pump, a polypropylene hollow fiber membrane oxygenator, and a heparin-coated circuit (Fig 2). The most important benefit of this system is its autopriming, which requires less than five minutes to prime the circuit before use and does not require specially trained personnel. Once the femoral cannulation was established, the PCPS system could be run to stabilize the patient. No hypothermia was applied. If possible, we tried to maintain the hematocrit above 35%, the platelet count above 100,000 per μl and the activated clotting time (ACT) at 150 to 200 seconds to minimize complications of bleeding and thromboembolic complications. After weaning the patients from the PCPS, we surgically removed the femoral artery and venous cannulae and repaired the cannulation sites to avoid ischemic limb complications.

3.3 Results

The clinical characteristics of the patients are listed in Table 4. All patients received VA PCPS and 44 patients (55.7%) had IABP concomitantly, as shown in the Table 4. The data on complications and events are shown in Table 5.

Forty-seven patients (59.5%) were weaned from the PCPS in both groups. Twenty-two patients (48.9%) in the cardiac arrest group could be weaned from the PCPS; the mean duration for PCPS in these patients was 63.1 ± 60.1 (range, 1 to 226; median, 52) hours. Twenty five patients (73.5%) in cardiogenic shock group were weaned from the PCPS; the mean duration for PCPS in these patients was 71.4 ± 66.2 (range, 1 to 306; median, 57) hours. Thirty three patients (41.8%) were discharged from the hospital; fifteen patients (33.3%) were in the cardiac arrest group and eighteen patients (50.0%) were in the cardiogenic shock

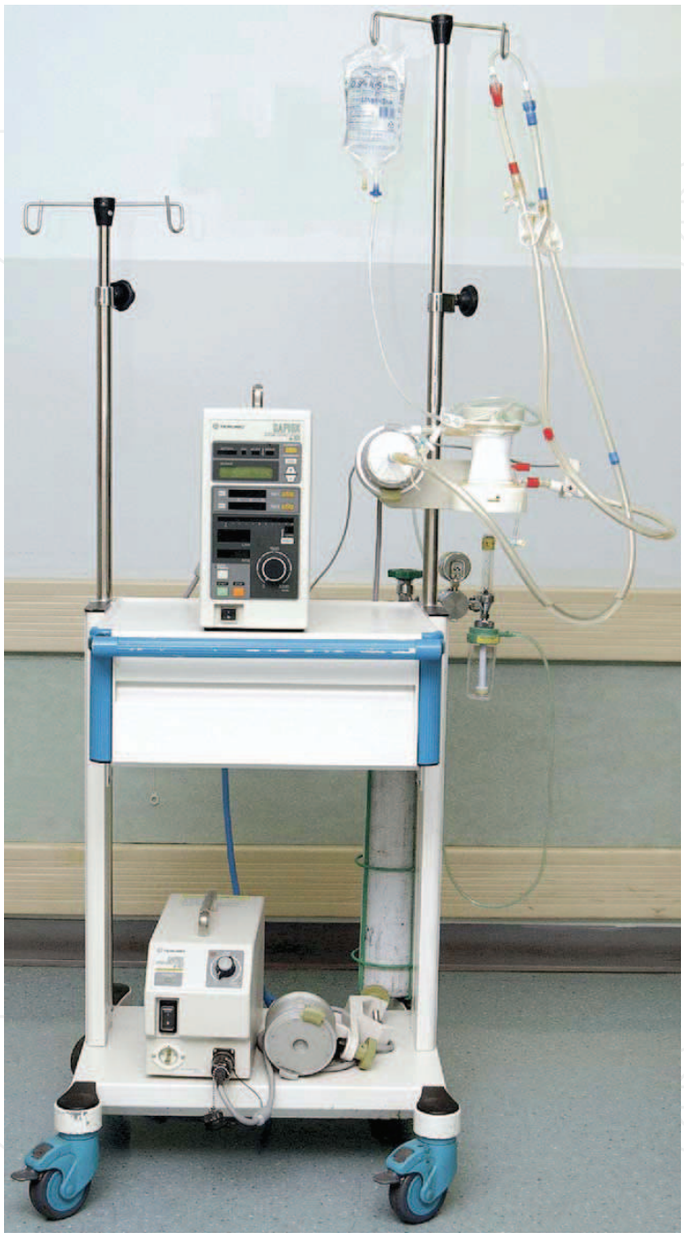


Fig. 2. The percutaneous cardiopulmonary support system used at our institution. It consists of a pump console, flowmeter, back-up console, and a holder for the centrifugal pump and oxygenator module with a drive motor. This system can be transported using a cart or clamped onto the bed. The emergency bypass system circuit, which consists of the centrifugal pump, oxygenator, and tubing, is sterilely packed.

	Refractory cardiac arrest	Cardiogenic shock
Patients	45	34
Age (years)	66.6 ± 12.8	65.5 ± 11.7
Male : Female	35 : 10	26 : 8
Timing of PCPS insertion		
Before PCI	24	14
During PCI	10	3
After PCI	11	17
Location of PCPS insertion		
Catheterization room	17	24
Intensive care unit	8	10
Emergency room	16	
Ward	4	
Concomitant use of IABP	22	22
Duration of PCPS (hours)	63.1 ± 60.1 (1 ~ 226)	71.4 ± 66.2 (1 ~ 306)
Weaning (%)	22 (48.9%)	25 (73.5%)
Survived to discharge (%)	15 (33.3%)	18 (50.0%)

PCI = percutaneous coronary intervention, PCPS = percutaneous cardiopulmonary support, IABP = intra-aortic balloon pump.

Table 4. Clinical characteristics

Complications	No.
Limb ischemia	8
Cannula site bleeding requiring revision	2
Cardiac tamponade requiring pericardiocentesis	2
Pulmonary hemorrhage	1
Hemothorax	1
Pneumothorax	1
Hemopneumothorax	1

Table 5. Complications associated with PCPS

group. There was no statistical difference in weaning from PCPS and survival discharge between the groups.

We divided 79 patients according to the timing of insertion, as follows: group A was instituted before coronary intervention; group B was instituted during intervention; and group C was instituted after intervention. In group A, 25 (65.8%) of 38 patients were weaned

from the PCPS and 18 (47.4%) patients survived to discharge; In group B, 8 (61.5%) of 13 patients were weaned from the PCPS and all patients survived to discharge; In group C, 14 (50%) of 28 patients were weaned from the PCPS and 10 (35.7%) patients survived to discharge. There was no statistical difference in weaning from PCPS and survival discharge between the groups.

4. Conclusion

Our results show that PCPS may be a feasible option as a procedural support during coronary intervention. Moreover, we suggest that rescue PCPS combined with early coronary revascularization by angioplasty may improve survival when acute coronary syndrome results in circulatory collapse, and PCPS should be considered in patients with no definite contraindications. However, further evaluation and investigation are needed because the limitations of the study included the absence of a control group for comparison and selection bias.

5. Acknowledgment

The author would like to acknowledge Mrs. Nam Kyung Choi for her dedicated assistance of manuscript editing and English revision.

6. References

Acker MA. (2001). Mechanical Circulatory Support for Patients With Acute-Fulminant Myocarditis. *Ann Thorac Surg*, 71:S73–6. ISSN 0003-4975

Aiyagari RM.; Rocchini AP. Remenapp RT. & Graziano JN. (2006) Decompression of the left atrium during extracorporeal membrane oxygenation using a transseptal cannula incorporated into the circuit. *Crit Care Med*, 34(10):2603-6. ISSN 0090-3493

Bartlett RH.; Gazzaniga AB. Jefferies MR. Huxtable RF. Haiduc NJ. Fong SW. (1976). Extracorporeal membrane oxygenation (ECMO) cardiopulmonary support in infancy. *Trans Am Soc Artif Intern Organs*, 22:80-93.

Bartlett RH. (1997) Extracorporeal life support registry report 1995. *ASAIO J*, 43:104–7, ISSN 1058-2916

Chen YS.; Lin JW. Yu HY. Ko WJ. Jerng JS. Chang WT. Chen WJ. Huang SC. Chi NH. Wang CH. Chen LC. Tsai PR. Wang SS. Hwang JJ. & Lin FY. (2008). Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis. *Lancet*, 372:554–561. ISSN 0140-6736

Cooper DS. Jacobs JP. Moore L. Stock A. Gaynor JW. Chancy T. Parpard M. Griffin DA. Owens T. Checchia PA. Thiagarajan RR. Spray TL. & Ravishankar C. (2007) Cardiac extracorporeal life support: state of the art in 2007. Cardiol Young, 17 Suppl. 2: 104–115. ISSN 1047-9511

Cohn, LH. (2008). *Cardiac surgery in the adult 3rd edition*, McGraw-Hill Education, http://cardiacsurgery.ctsnetbooks.org/

Ganslmeier P.; Philipp A. Rupprecht L. Diez C, Arlt M. Mueller T. Pfister K. Hilker M. & Schmid C. (2011). Percutaneous cannulation for extracorporeal life support. *Thorac Cardiov Surg*, 59: 103-7. ISSN 0171-6425

Grambow DW.; Deeb GM. Pavlides GS. Margulis A. O'Neill WW. & Bates ER. (1994) Emergent percutaneous cardiopulmonary bypass in patients having cardiovascular collapse in the cardiac catheterization laboratory. *Am J Cardiol*, 73:872-5. ISSN 0002-9149

Gravlee GP.; Davis RF. Stammers AH. & Ungerleider RM. (2008) Cardiopulmonary bypass principles and practice. 3rd edition, Lippincott Williams & Wilkins, ISBN 978-0-7817-6815-3, United States of America

Hitt E. (2008), CESAR trial: extracorporeal membrane oxygenation improves survival in patients with severe respiratory failure. *Medscape Medical News www.medscape.com*; [accessed 21.05.08]

Hill JD.; De Leval MR. Fallat RJ. Bramson ML. Eberhart RC. Schulte HD. Osborn JJ. Barber R. & Gerbode F. (1972) Acute respiratory insufficiency. Treatment with prolonged extracorporeal oxygenation. *J Thorac Cardiovasc Surg*, 64(4):551-62. ISSN 0022-5223

Kawahito K.; Ino T. Adachi H. Ide H. Mizuhara A. & Yamaguchi A. (1994) Heparin coated percutaneous cardiopulmonary support for the treatment of circulatory collapse after cardiac surgery. ASAIO J, 40:972-6. ISSN 1058-2916

Koenig PR.; Ralston MA. Kimball TR. Meyer RA. Daniels SR. & Schwartz DC. (1993). Balloon atrial septostomy for left ventricular decompression in patients receiving extracorporeal membrane oxygenation for myocardial failure. *J Pediatr*, 122:S95-9. ISSN 0022-3476

Kolobow T.; Solca M. Gattinoni L. & Pesenti A. (1981) Adult respiratory distress syndrome (ARDS): why did ECMO fail? *Int J Artif Organs*. 4(2):58-9. ISSN 0391-3988

Kurusz M.; Zwischenberger JB. (2002) Percutaneous cardiopulmonary bypass for cardiac emergencies. *Perfusion*, 17:269-77. ISSN 0267-6591

Meurs KV.; Lally KP. Peek G. & Zwischenberger JB. (2005) ECMO: Extracorporeal cardiopulmonary support in critical care. 3rd edition, ELSO, ISBN 0-9656756-2-9, United States of America

Marasco SF.; Lukas G. McDonald M. McMillan J. & Ihle B. (2008). Review of ECMO (extra corporeal membrane oxygenation) support in critically ill adult patients. *Heart Lung Circ*, 17 Suppl 4:S41-7. ISSN 1443-9506

Nagao K.; Hayashi N. Kanmatsuse K. Arima K, Ohtsuki J, Kikushima K,.& Watanabe I (2000) Cardiopulmonary cerebral resuscitation using emergency cardiopulmonary bypass, coronary reperfusion therapy and mild hypothermia in patients with cardiac arrest outside the hospital. *J Am Coll Cardiol*, Sep;36(3):776-83. ISSN 0735-1097

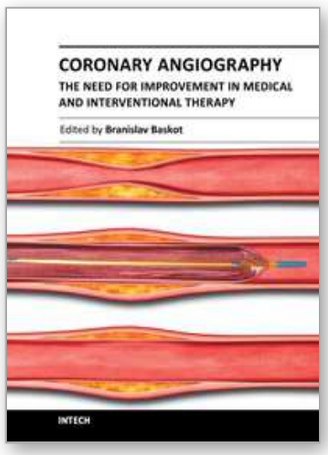
Patel H.; & Pagani FD. (2003) Extracorporeal mechanical circulatory assist. *Cardiol Clin*. 21(1):29-41. ISSN: 0733-8651

Peek GJ.; Clemens F. Elbourne D. Firmin R. Hardy P. Hibbert C. Killer H. Mugford M. Thalanany M. Tiruvoipati R. Truesdale A. & Wilson A. (2006) CESAR: conventional ventilatory support vs. extracorporeal membrane oxygenation for severe adult respiratory failure. *BMC Health Serv Res*, 23(6):163, http://creativecommons.org/liscences/by/2.0

Rousou JA.; Engelman RM. Flack JE 3rd. Deaton DW. & Owen SG. (1994) Emergency cardiopulmonary bypass in the cardiac surgical unit can be a lifesaving measure in post-operative cardiac arrest. *Circulation*, 90:1280-4. ISSN 0009-7322

Schwarz B.; Mair P. Margreiter J. Pomaroli A. Hoermann C. Bonatti J. & Lindner KH. (2003) Experience with percutaneous venoarterial cardiopulmonary bypass for emergency circulatory support. *Crit Care Med*, 31(3):758-64. ISSN 0090-3493

Sung K. Lee YT. Park PW. Park KH. Jun TG. Yang JH. & Ha YK. (2006) Improved survival after cardiac arrest using emergent autopriming percutaneous cardiopulmonary support. *Ann Thorac Surg*, 82 suppl 2:651-6. ISSN 0003-4975



Coronary Angiography - The Need for Improvement in Medical and Interventional Therapy

Edited by Prof. Baskot Branislav

ISBN 978-953-307-641-6
Hard cover, 206 pages
Publisher InTech
Published online 06, September, 2011
Published in print edition September, 2011

In this book we examined a periprocedural complication of coronary angiography, and coronary intervention. That includes related to cardiac catheterization and diagnostic coronary angiography, and those that occur as a consequence of the specific equipment. However, improvements in devices, the use of stents, and aggressive antiplatelet therapy have significantly reduced the incident of major periprocedural complications. This book giving knowledge and experiences many of interventional cardiologists from all over the world, and provide possibility to recognize new approach in this domain. Book gives lecture on how we image and how we decide on what to treat, how to treat it, and then results of that treatment. They offer many answers to what we have today and what we will have tomorrow.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen