ECMO SUPPORT IN EARLY POSTOPERATIVE CARDIAC FAILURE

A. GÜRBÜZ, M.D.,
S. AKEL, M.D.,
E. AKINCI, M.D.,
M. TUZCU, M.D.,
Ö. IŞIK, M.D.,
and
C. YAKUT, M.D.

From: Koşuyolu Heart and Research Hospital

Adress for reprints:
A. GÜRBÜZ, MD.
Koşuyolu Heart and Research Hospital
İstanbul, TÜRKİYE

Early postoperative low cardiac output syndrome is a major cause of hospital mortality in open heart surgery. In most patients hemodynamic stabilization is achieved by symptomatic treatment, inotropic medicattion, and intraaortic balloon pump (IABP) support. However, in some patients, despite these measures death is imminent.
This study covers 127 open heart surgery patients who had cardiac arrest in the postoperative period, and who were refractory to recussitation. They were taken back to the operating room, sternotomies were reopened, and extracorporeal membrane oxygenation (ECMO) was instituted via right atrial and ascending aorta accesses. Of the 127 patients, 48 could not be weaned off ECMO support and died, however, 79 patients were weaned off. Twenty-six of 79 died on 1st – 26th postoperative days, and 53 patients got well and were discharged from the hospital in good physical condition. Four patients in this group died in the first year due to congestive heart failure.
Additionally, in three patients who had developed cardiac failure in the cath lab following PTCA, ECMO support was used via femoral artery and vein accesses. Two of these patients survived. In another patient with high-risk PTCA, ECMO support was initiated prior to intervention.
In the early postoperative period, evolving low cardiac output or sudden cardiac arrest sometimes cannot be managed by conventional resusciative measures. In such stiuations cardiopulmonary support may save lives.

Key words: Open heart surgery, postoperative cardiac failure, extracorporeal membrane oxygenation.

Sudden cardiac death accounts for approximately 300 000 deaths annually in the USA, nearly 50% of all cardiovascular deaths (1). Techniques of closed chest massage for cardiopulmonary recussitation (CPR) were popularized by Dr. William Kauenhoven in 1960 (2). Since then, different methods of circulatory asistance have been applied to cardiopulmonary recussitation techniques in an effort to improve survival (3).
In 1983 Bedell and colleagues reported that only 14% of patients who survived in-hospital cardiac arrest were successfully discharged (4). With better understanding of extracorporeal circulation and with im-

Table 1: Primer surgical procedures

	Patient	%
CABG	94	74
CABG+Aneurysmectomy	10	7.8
MVR	4	3.1
AVR	8	6.2
AVR+MVR	9	7
TOF	1	0.7
CABG+AVR	1	0.7

Table 2: Causes of postoperative cardiac failure

	Patient	%
Malignant arrythmia	57	44.8
Peropt AMI	40	31.4
Massive bleeding	10	7.8
Elektrolyte and metabolik imbalance	3	2.3
Hyperthermia	2	1.5
ARDS	10	7.8
Unknown	3	2.3
Valve dysfunction	2	1.5

provements in perfusion techniques, cardiopulmonary support was utilized with the use of femoral artery and vein in cases where cardiac arrest was considered reversible (5,6).

Material and Methods

Between February 1985 – February 1993, 5746 open heart operations were performed at the Koşuyolu Heart and Research Hospital. Of these operations, 3393 (59.1%) were coronary artery bypass grafting (CABG/ procedures, 1750 (30.5%) were valvular procedures, and 603 (10.4%) were congenital and other corrective procedures. From this surgical pool, 127 patients developed low cardiac output syndrome, sudden cardiac arrest, or intractable ventricular fibrillation that did not respond to conventional recussitative therapy, and therefore, ECMO support was started. While decision for ECMO support is given, the patient was rushed into the operating room with external cardiac massage, the sternum was opened, and right atrial venous and aortic arterial cannulas were placed, setting everything ready for ECMO support. ECMO consists of a membrane oxygenator, a heat exchanger, and a roller or centrifugal pump.

Age distribution of the patients ranged between 10 – 74 (Mean 56). Ninty-nine patients (77.9%) were male and 28 (22.1%) were female. Primary surgical procedure was CABG in 104 patients (81.8%). (Table 1)

In 50 patients (39.3%) ECMO support was started within 6 hours postoperatively. (Figure 1) Cardiac failure was due to malignant arrythmias and peroperative myocardial infarction in 76.3% of these patients. (Table 2) ECMO support time ranged between 30 min – 52 hours (mean 3 hours). In 112 of the patients (88.1%), fluid overload and hemodilution due to reperfusion was treated by hemofiltration. IABP support was used previous to ECMO support in 30

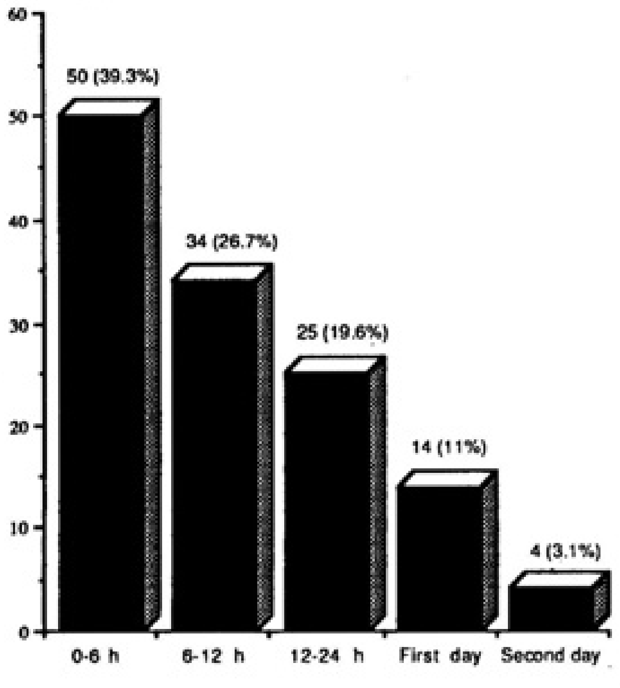

Figure 1: Postoperative ECMO support starting imes.

Table 3: Surgical procedures concomittant to ECMO support

Aorta distal LAD saphenous vein bypass	6
Graft thrombectomy	5
Aortic root reconstruction	2
Reoperation for massive hemorrahagic	10

patients (23.6%), during ECMO support in 68 patients (53.5%), and following ECMO support in 15 patients (11.8%). In 14 patients (11%) IABP and in 8 patients inotropic drug support was not required. In four patients IABP, placement was transmediastinal, into the ascending aorta, due to peripheral atherosclerosis. Roller pumps were used in the earlier 32 (25.1%) cases, but later centrifugal pumps were used in 95 (74.8%) patients. During ECMO support heparine dose was controlled by keeping activated clotting time between 350 – 400 seconds. During ECMO support initial flow rate was kept at 2 L/m²/min, and as the hemodynamic parameters improved, the flow rate was decreased with slowly weaning the patient off.

During ECMO support, in 13 patients (10.3%) surgical procedure was modified with the use of aortic cross clamp. In 6 of these patients, Aorta – distal LAD saphenous vein grafts, in 5 patients, thrombectomy due to early graft thrombosis, and in 2 patients aortic root reconstruction was performed. Additionally, in 10 patients tamponade was releived with control of postoperative bleeding. (Table 3).

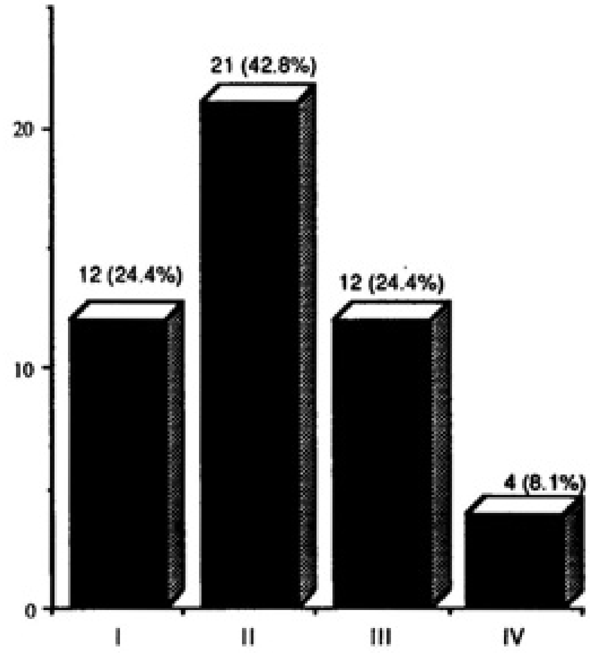

Figure 2: Postoperative clinical status of the patients according to NYHA classification.

Results

Despite ECMO support lasting 3 – 52 hours, 48 patients (37.7%) died. In 79 patients (62.3%) ECMO support lasting between 30 minutes to 12 hours (Mean 150 min) had a successful outcome. Twenty-six of these patients (32.9%) died in the early postoperative period. (Table 4) Fifty-three (67%) were discharged from the hospital. Four of the discharged patients died in the first postoperative year due to congestive heart failure. Clinical condition of the living patients according to the NYHA classification is given in Figure 2.

Table 4: Causes of mortality

	İntraoperative (48 patients)	Postoperative (26 patients)
Pump failure	31	12
Multi organ failure	10	12
Bleeding caused by DIC or thrombocytopenia	7	1
Infection and sepsis		6
Pulmonary embolism		2
Cerebrovascular accident		2

One patient required high-risk elective angioplasty. He was maintained on femoro-femoral CPB for approximately 30 minutes while a critical LAD lesion was dilated.

In three patients with failed angioplast, two developed refractory ventricular fibrillation and one was asystolic. These patients underwent emergency coronary artery revascularization, after the institution of ECMO support. There was one surviver. While being recussitated, these three patients were transferred to the operating room, and ECMO support was started.

One patient had undergone total correction for TOF, developed untractable pulmonary edema due to hypoplastic left ventricle. ECMO support was started, however the patient didn't survive.

Discussion

Despite significant advances in myocardial protection and surgical techniques, postoperative cardiogenic shock still occurs in 2 – 8 % of patients undergoing open heart surgery. Low cardiac output is mostly seen in the first 48 hours postoperatively, and has many etiologic causes. In the great majority of patients (90%), early diagnosis of this clinical condition, initiation of symptomatic treatment, correction of electrolyte imbalance and metabolic disorder, establishment of optimal filling pressures, use of inotropic agents, vasodilator agents, and IABP support provides a favorable outcome. (7,8)

Despite optimal preload, maximal drug therapy, corrected metabolism, and IABP support, if cardiac index is < 2 L/m^2/min, systemic vascular resistance > 2100 dynes/sec/cm^3, atrial pressure > 20 mmHg, and urine output < 20 ml/h, temporary ventricular assist (Left ventricular assist, right ventricular assist, or biventricular assist) is required. (9,10)

Sudden cardiac arrest, cardiac arrest due to low cardiac output, or ventricular fibrillation refractory to drug therapy is treated by conventional cardiopulmonary recussitation. Closed cardiac massage can only provide 10% of normal cerebral and 5% of normal myocardial blood flow. (11) Many years have passed over the use of cardiopulmonary recussitation, but in-hospital recussitation still carries a poor prognosis, with only 14% surviving to leave the hospital. (4)

IABP alone significantly reduces afterload and somewhat the preload. Systolic wall stress decreases, coronary blood flow increases, and myocardial contractility improves. (12) However, IABP is depended on a certain level of left ventricular function which limits its benefits in severe ventricular arrythmias, asystoly, and ventricular arrest. (13)

The concept of extracorporeal cardiopulmonary circulation was set forth by Gallois, in 1813 (14), although it did not become a clinical reality until 1953, as performed by Gibbon. (15).

ECMO support has been used in emergency services, catheterization labs, and intensive care units by many investigators. (6,14) Some of the indications for use of ECMO are acute myocardial infarction, failed PTCA, elective PTCA in high risk patients, hypothermia, malignant hyperthermia, pulmonary embolism, refractory ventricular fibrillation, adult and infant respiratory distress syndrome, drug intoxication, sepsis, trauma, recussitation of post cardiotomy syndrome. ECMO can be performed either by femoral vein – femoral artery — right internal jugular vein – femoral artery percutaneously or with a sternotomy via the right atrium and ascending aorta.

Mattox reported 39 patients in a mortal state who were placed on a portable cardiopulmonary bypass: 15 were long-term survivers, 13 of them had massive pulmonary embolus. (14)

Phillips and collegues reported 21 patients with refractory cardiac arrest. Seventeen patients could be recussitated. (5)

The use of ECMO for the treatment of neonatal pulmonary failure was first popularized by Bartlett and associates. (16) Redmond, et al used ECMO on 40 patients with acute respiratory failure and 36 (90%) survived. (17)

It has been demonstrated that ECMO improves tissue perfusion as evidenced by correction of acidosis and ability to cardiovert the heart to regular rhythm. (18) The combination of ECMO and IABP significantly reduces end-diastolic volumes and systolic wall stress, coronary artery blood flow increases and left ventricular oxygen consumption decreases. (12)

In our case, excluding the patient with ECMO support in the catheterization lab, all our patients were recussitated for postcardiotomy syndrome. For this reason, because all of the patients had a sternotomy done previously, they were all conviniently taken back to the operating room, their sternotomies reopened, and ECMO support started by cannulating the right atrium and the aorta. We were able to save 41.7% of these patients, who otherwise would have 100% mortality witout ECMO support. With these results in hand, we feel that ECMO support should be used in all postoperative open heart surgery patients developing cardiac arrest or fibrillation refractory to conventional cardiopulmonary recussitative intervention.

The major disadvantages of ECMO support is that it requires heparinization, causes destruction of blood elements and multi-system failure after long term use, due to non-physiological tissue perfusion.

References

1- Myerburg RJ., Castellanos A.: Cardiac arrest and sudden cardiac death. In: Braunwald E, ed. Heart Disease. A textbook of Cardiovascular Medicine; 4nd ed. Philadelphia: W.B. Saunders, 1992: 756

2- Kouwenhoven WB, Jude JR, Knickerbocker GG.: Closed Chest Cardiac Massage. JAMA 1960; 173: 1064-1067

3- American Heart Association. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). JAMA 1980; 244: 462-468

4- Bedell SE, Delbanco TL, Cook EF, Epstein FH.: Survival after cardiopulmonary resuscitation in the hospital. N Eng J Med 1983; 309: 569-608

5- Phillips SJ, Ballentine B, Slonine D, et al.: Percutaneous initiation of cardiopulmonary bypass. Ann Thorac Surg 1983; 36: 223-225

6- Phillips SJ, Zeff RH, Kongtahworn C et al. Percutaneous cardiopulmonary bypass: Application and Indication for use. Ann Thorac surg 1989; 47: 121-123

7- Pennigton DG, Swartz M, Codd JE, Merjavy JP, Kaiser G.: Intra-aortic balloon pumping in cardiac surgical patients: a nine-year experience. Ann Thorac Surg 1983; 36: 125-131

8- Kirklin JW, Barratt-Boyes BG. Cardiac Surgery; 2 nd ed. New York; Churchill Livingstone Inc, 1993; 195

9- Pennington DG, Joyce LD, Pae WE, Burkholder JA.: Patient Selection. Ann Thorac Surg 1989; 47: 77-81

10- Hill DJ, Hardesty RL, Baumgartner WA, Rose DM.: Intraoperative management. Ann Thorac Surg 1989; 47: 82-87

11- Wexler HR, Gelb AW.: Controversies in cardiopulmonary resuscitation. Crit Care Clin 1986; 2: 335-348

12- Bavaria JE, Furukowa S, Kreizer G, et al.: Effect of circulatory assist devices on stunned myocardium. Ann Thorac Surg. 1990; 49: 123-128

13- Rosenberg I: Circulatory support by IABP and by centrifugal pumps. In: Olin C, Fahraeus T, Solem JO Eds. Management of low cardiac output after open heart surgery. Proceeding of the third Scandinavian Postgraduate Course in Cardiac Surgery. Sweden 1986; 63-72

14- Mattox KL, Beall AC Jr.: Resuscitation of the moribound patient using portable cardiopulmonary bypass. Ann Thorac Surg 1976; 22: 436-442

15- Gibbon JH: Antificial maintenance of circulation during experimental occlusion of pulmonary artery. Arc Surg 1937; 34: 1105-1108

16- Barlett RH, Gazzaniga AB, Huxtable RF, et al.: Extracorporeal circulation (ECMO) in neonatal failure. J Thorac Cardiovasc Surg 1977; 74: 826-833

17- Redmond CR, Graves ED, Falterman KW, et al.: Extracorpeal membrane oxygenation for respiratory and cardiac failure in infants and children. J Thorac Cardiovasc Surg 1987; 93: 199-204

18- Reichman RT, Colin I, Dembitsky WB, et al.: Improved patient survival after cardiac arrest using a cardiopulmonary support system. Ann Thorac Surg 1990; 49: 101-105