ECMO SUPPORT IN EARLY POSTOPERATIVE CARDIAC FAILURE

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

From: Koşuyolu Heart and Research Hospital

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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 medication, 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 resuscitation. 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 resuscitative measures. In such situations 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 resuscitation (CPR) were popularized by Dr. William Kauenhoven in 1960 (2). Since then, different methods of circulatory assistance have been applied to cardiopulmonary resuscitation 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

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Patient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG</td>
<td>94</td>
<td>74</td>
</tr>
<tr>
<td>CABG+Aneurysmectomy</td>
<td>10</td>
<td>7.8</td>
</tr>
<tr>
<td>MVR</td>
<td>4</td>
<td>3.1</td>
</tr>
<tr>
<td>AVR</td>
<td>8</td>
<td>6.2</td>
</tr>
<tr>
<td>AVR+MVR</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>TOF</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>CABG+AVR</td>
<td>1</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Improvements 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 resuscitative 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). Ninety-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 arrhythmias 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 times.
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 relieved with control of postoperative bleeding. (Table 3).

Table 3: Surgical procedures concomittant to ECMO support

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorta distal LAD saphenous vein bypass</td>
<td>6</td>
</tr>
<tr>
<td>Graft thrombectomy</td>
<td>5</td>
</tr>
<tr>
<td>Aortic root reconstruction</td>
<td>2</td>
</tr>
<tr>
<td>Reoperation for massive hemorrhagic</td>
<td>10</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>Intraoperative (48 patients)</th>
<th>Postoperative (26 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump failure</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>Multi organ failure</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Bleeding caused by DIC or thrombocytopenia</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Infection and sepsis</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

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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 survivor. While being resuscitated, 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/m²/min, systemic vascular resistance > 2100 dyn/sec/cm³, 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 resuscitation. 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 resuscitation, but in-hospital resuscitation 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 arrhythmias, 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, resuscitation of post cardiomyopathy 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 survivors, 13 of them had massive pulmonary embolus. (14) Phillips and colleagues reported 21 patients with refractory cardiac arrest. Seventeen patients could be resuscitated. (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 resuscitated for postcardiotomy syndrome. For this reason, because all of the pa-
tients had a sternotomy done previously, they were all conviently 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 without 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 recusitative 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


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


