

Percutaneous Cardiopulmonary (Bypass) Support in the Cardiac Catheterization Laboratory: A New Application of Perfusion

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Key words: PTCA, cardiac catheterization, cardiopulmonary support, extracorporeal circulation

ABSTRACT

Percutaneous cardiopulmonary bypass support (PCPS) has been introduced in the catheterization laboratory to support high risk coronary angioplasty, as well as emergencies. We report the safety and feasibility of PCPS in 45 patients. Thirty-seven patients (Group 1) were elective and eight were emergencies (Group 2). Group 1 (ages 41-82) were high risk coronary angioplasty, Group 2 (ages 40-82) were in cardiogenic shock due to myocardial infarction with two in cardiac arrest. Cannulation of femoral artery and vein was with 20 French cannulae. Priming of the system with 1400 ml of Normosol was achieved in 5-7 minutes. Cardiopulmonary bypass was then instituted using the Bard CPS system after full heparinization (300 units per kilogram). Flows ranged from 2.8-5.5 liters per minute (mean=3.8) and pulmonary diastolic pressures were 0-4 mm Hg. Two patients in cardiac arrest regained consciousness while still in ventricular fibrillation or asystole. The activated clotting time ranged from 317-880 seconds (mean=498). Mean bypass time was 37 minutes (range 10-73) in Group 1 and 66 minutes (range 44-120) in Group 2. Total infusion volume of Normosol during and prior to termination of bypass was 0-2500 cc (mean=338). There were no procedural complications associated with PCPS. We conclude that PCPS can be used safely in selected patients who are considered high risk for PTCA or acute MI complicated by shock or cardiac arrest. This technology adds a new dimension in perfusion in the catheterization laboratory.

INTRODUCTION

Interventional procedures in the cardiac catheterization laboratory such as percutaneous transluminal coronary angioplasty have been limited by the risk of hemodynamic collapse due to acute closure¹ of the target vessel or hemodynamic compromise during the balloon inflation of an artery that is supplying the only remaining viable myocardium. Furthermore, for patients in cardiogenic shock, the risk of interventional procedure remains very high. Intra-aortic balloon counterpulsation has been used to support patients hemodynamically during interventional procedures, but this has been of limited application in cases of hemodynamic collapse.

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Without an intrinsic rhythm, the balloon pump is not effective. Cardiopulmonary bypass support has been used to support patients during such high risk cardiac catheterization laboratory procedures but until recently,² access to the femoral artery and vein has required a surgical cutdown.³

METHODS

These procedures were performed in the cardiac catheterization laboratory of the Washington Adventist Hospital, Takoma Park, Maryland. Patients were prepped and draped in a sterile fashion. For elective cases, iliofemoral angiography was performed to assess the suitability of the iliofemoral system for the insertion of the bypass cannulae. In emergency situations, iliofemoral angiography was not performed. A Swan-Ganz catheter was inserted for hemodynamic measurements before, during, and after cardiopulmonary bypass support. A standard angioplasty introducer was placed in the same groin. In the contralateral groin, access to the femoral artery and vein were obtained. Heparinization was established (300 units per kilogram body weight). A long femoral sheath was placed in the femoral artery (over a standard "J" tip guidewire). The artery was dilated progressively using 12 French and 14 French dilators over a stiff wire. The 18 or 20 French cannulae were then advanced over these stiff guidewires. The arterial cannula was advanced to the level of the common iliac artery. The cannula on the venous side was advanced to the level of the cavo-atrial junctions.

The cardiopulmonary support system, CPS^a, was readied while the cardiologist placed the arterial and venous bypass cannulae. The system employed 1400 cc of Normosol. The cannulae were then connected to the CPS circuit which uses 3/8" polyvinylchloride tubing. These cannulae were connected to the Bard portable cardiopulmonary bypass support system, which uses a centrifugal, non-occlusive pump, a polypropylene hollow fiber membrane oxygenator and heat exchanger.

Prior to coronary angioplasty, the patients were placed on partial bypass with an average flow rate of two liters per minute, range two to five liters per minute. The flow was increased if pulmonary diastolic pressure was greater than five, or if chest pain or hypotension occurred during balloon inflation. For patients in cardiogenic shock, an estimate of the blood flow requirement was calculated based on patients body surface area

a. C.R. Bard, Inc., Billerica, MA

or body weight (2.2-2.4 liters per minute per square meter or 50-60 ml per kilogram of body weight). Coronary angioplasty was then performed through the contralateral femoral artery. Following successful angioplasty cardiopulmonary support was terminated over two to three minutes and the cannulae were clamped. During the termination of bypass, volume was infused to achieve a pulmonary capillary wedge pressure (pulmonary artery diastolic pressure) to 8-10 mm Hg or at least to the prebypass level. When the patient appeared clinically stable, both cannulae were removed and an external compression clamp was applied for hemostasis after the patient was placed on a special stretcher. The heparin was not reversed.

A total of 45 patients underwent cardiopulmonary bypass support using a percutaneous technique. Thirty-seven patients (Group 1) were operated electively and eight were emergencies (Group 2). Group 1 (ages 41-82 years, mean 62) were considered high risk for coronary angioplasty and Group 2 (ages 40-80, mean 63) were in cardiogenic shock due to evolving acute myocardial infarction with two patients in cardiac arrest.

CPS flows ranged from 2.8-5.5 liters per minute (mean=3.8) and pulmonary diastolic pressures were at 0-4 mm Hg. The activated clotting time (ACT) ranged from 317-838 seconds (mean=498). Mean bypass time was 37 minutes, (range 10-730) in Group 1 and 66 minutes, (range 44-120) in Group 2 patients.

In Group 1 patients, successful angioplasty was performed in 86 of 87 lesions (98%). These patients were able to tolerate prolonged balloon inflation without hemodynamic instability. In Group 2, (eight patients), seven underwent coronary angioplasty after the hemodynamics were stabilized on bypass support. These seven patients then underwent successful coronary angioplasty in 15 of 16 vessels. The eighth patient had anatomy unsuitable for surgery or angioplasty, and therefore expired once he was taken off bypass. The two patients in cardiac arrest regained consciousness while their rhythm varied from ventricular asyatole to fibrillation.

Total volume infusion during and prior to termination of bypass was ranged from 0-2500 cc (mean 338).

There were no major complications associated with the cardiopulmonary bypass support system.

DISCUSSION

Cardiopulmonary bypass in the cardiac catheterization laboratory to support patients during complex procedures, cardiogenic shock, or arrest represents a new use and application of extracorporeal circulation. Percutaneous cardiopulmonary bypass support was used safely and without hemodynamic complications. There were no adverse renal, respiratory, or neurologic complications. The difficulties encountered related more to the coronary anatomy and hemostasis after removal of the cannulae.²

The patients who underwent supported angioplasty were patients who would not have otherwise been considered candidates for percutaneous transluminal coronary angioplasty in a cardiac catheterization laboratory. These patients had either

been referred for surgery or had been turned down for surgical intervention.⁴ Cardiogenic shock due to acute myocardial infarction is associated with a mortality rate of 80 to 90%. All seven of the emergency group patients with successful coronary angioplasty survived and were discharged from the hospital.⁵

In summary, cardiopulmonary bypass support in the cardiac catheterization laboratory represents a new application of perfusion technology, and therefore can support, effectively, high risk angioplasty and cardiogenic shock patients undergoing interventional procedures.

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