Prolonged CPB in Patients Requiring Extensive Coronary Endarterectomy and Reconstruction

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ABSTRACT

The technique of coronary endarterectomy and reconstruction continues to be a tedious and time consuming effort. A 14 cm. endarterectomy of a diffusely diseased LAD, with accompanying diagonal branches and septal perforators, can require as long as 90-115 minutes of aortic clamp time. Multiple endarterectomies, including marginal branches of the circumflex system as well as multiple branches of the right coronary system, can consume an additional 100-125 minutes of aortic clamp time. It is not uncommon for total clamp time to exceed 200 minutes. Because of the totally occlusive nature of the disease, cardioplegia is impossible to deliver. As a result, the method of intermittent ischemic arrest proves to be the technique of choice. It has become necessary to develop a perfusion protocol which will support the surgical procedure that can last a total of 300 to 420 minutes on CPB. Hollow-fiber membrane oxygenation, normal physiological arterial and venous gases, and scrupulous attention to the CPB circuit, is imperative if the patient is to derive a long term benefit from the procedure. The conduct and technique of CPB which has been developed with Milwaukee Heart Surgery Associates has allowed the surgeons the time and margin of safety required to perform coronary endarterectomy and reconstruction.

INTRODUCTION

In order to support the lengthy surgical technique of coronary endarterectomy and reconstruction while on CPB, it has become necessary to develop a special perfusion protocol that allows our surgeons the time required to complete this tedious procedure. During this surgical alchemy, the perfusionist must provide the most physiological state of extracorporal circulation possible and maintain the widest margin of safety.

The purpose here is to briefly describe the protocol established at Milwaukee Heart Surgery Associates that enable the perfusionist to support the patient over a prolonged period of time and successfully terminate CPB with a minimum of complications.

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METHODS AND MATERIALS

A three-module, stacked Pemco[a] heart-lung machine with a modified double roller systemic pump capable of a maximum flow rate of 9L/min. is the standard support system.

The 5/8 in. silastic pump head, secured into the 21 inch raceway, allows for the increased flow requirements demanded by patients who have been on calcium channel blocker therapy. Hollow fiber membrane oxygenation utilizing the Bentley[b] BOS CM-50 or Bard[c] H-F 4000 allows for control of arterial and venous blood gases which are continuously monitored with the CDI[d] GAS-STAT System.

Arterial line filtration is accomplished by the use of the Bentley[b] AF1025C Duraflo 25 micron filter modified with a single three-way stopcock which allows for monitoring the back pressure and a continuous purge line to the Bentley[b] 3500 filtered cardiotomy reservoir simultaneously.

An 8.0 Sarns[e] cannula is used at the aortic site while maximum drainage is accomplished by insertion of either Sarns or USCI cannulas into the superior and inferior vena cavae. Size of these cannulae is determined by the size of the patient. The aortic root is vented using a 16 Fr. USCI cannula. This method allows for good LV decompression as well as providing efficient air evacuation as the I aortic clamp is opened. Because of the totally occlusive disease present in the coronary arteries, delivery of cardioplegia would be ineffective at best, subsequently, intermittent ischemic arrest is the only method of myocardial preservation possible. By maintaining the body temperature at 34°C, the heart will often spontaneously convert when the aorta is open for five minutes after 15-20 minutes of ischemic arrest.

The prime consists of three liters of Plasmaltye 7.4, 25 gm. of mannitol, 50 cc. of $NaHCO_3$, and 5,000 units of porcine heparin. (for patients less than 50 kg., 1,000 cc. of prime is drained from the perfusion circuit and one unit of cell mass is added if the hematocrit is less than 30). All patients received 100 cc. of albumin 25% at the onset of CPB and a 12.5 gm. dose of Mannitol every hour while on bypass. A pre-heparin ACT is drawn for a baseline value and a loading dose of 500 units /kg. of

a. Pemco, Cleveland, OH
b. Bentley, Irvine, CA
c. CR Bard, Billerica, MA
d. CDI, Irvine, CA
e. Sarns/3M, Ann Arbor, MI

porcine heparin is administered two to three minutes prior to bypass. ACT's are calculated by the use of a dual chambered Hemocron unit and sampling is done every 30 minutes maintaining a value of greater than 500 seconds.

Normal physiological arterial and venous blood gases are maintained regardless of temperature. Adequacy of perfusion is based upon venous blood gas values. With the CDI GAS-STAT System, we are able to monitor the performance of the oxygenator by observing the on-line/real-time arterial blood gases and by the trending of venous gases, we are able to establish the adequacy of perfusion.

RESULTS

From January, 1986 to July, 1987, 773 patients had undergone myocardial revascularization with 310 patients requiring extensive coronary, endarterectomy and reconstruction. Of the 35 randomly selected patients, 33 were male and two were female with a mean age of 55.4 years. Mean bypass time was 321 minutes while total ischemic time averaged 188 minutes. Systemic vascular resistance was a mean of 917 $\pm$ 30 and perfusion pressure (MAP-CVP) was a mean of 63 mm/H9 $\pm$ 13. Urine production while on bypass averaged 2,345 cc. per patient. Table 1 demonstrates the continously monitored blood gas results as well as the hourly Hct. and K+.

In this group of 35 patients, there were four deaths. One patient was pronounced in the OR after numerous attempts at short term support and IABP insertion and pharacological therapy. Total time on bypass was 545 minutes with total ischemic time totaling 321 minutes. This patient required extensive reconstruction of three arteries, two conventional grafts, and an aortic valve replacement, for which cold blood cardioplegia was administered as a myocardial preservative. The three other patients died in the immediate post-operative recovery period due to multi-system failure. Ejection fractions (EF) ranged from .20 to a normal EF of .65. Ten (28%) patients had Class I ventricles, 17 (48%), patients had Class II ventricles, and eight (24%), patients had Class III ventricles. Forty-two percent of the patients were reoperations.

DISCUSSION

The majority of the patient population referred to Milwaukee Heart Surgery Associates suffers from end-stage coronary artery disease and have been refused surgery at various centers. The typical patient has severely diffuse triple vessel disease along with other multiple risk factors. The surgical technique carries an inherently high risk by itself. This, compounded by low ejection fractions, insulin-dependent diabetes, poor renal function, and the fact that 41% of these patients have had coronary artery surgery in the past all pose a challenge of the highest magnitude to the surgeon and perfusionist.

By providing the most physiological perfusion possible and using state-of-the-art equipment, we are able to support the patient with minimizing some of the hazards associated by prolonged CPB. No perfusionist is afforded the luxury of picking his or her patient and in order to avoid any potential catastrophy, it is imperative that the perfusionist be prepared for any eventuality.

In a clinical setting such as this, it is not uncommon to be on bypass for over six hours. Stress, mental fatigue, and loss of concentration pose the greatest hazard to the perfusionist. Level sensors and pressure alarms are imperative, but in the final analysis, the best deterrent to a potential hazard or catastrophe is an alert perfusionist.

TABLE 1

(mean $\pm$ standard deviation)

Arterial Values		Venous Values	
pH	7.43 $\pm$ 04	pH	7.37 $\pm$ 0.3
pCO2	38 $\pm$ 3	pCO2	43 $\pm$ 4
pO2	110 $\pm$ 15	pO2	31 $\pm$ 6
SaO2	97% $\pm$ 2	SvO2	67 $\pm$ 5
Hct	23 $\pm$ 4		
K+	4.6 $\pm$ 1.1		

In this group of 35 patients there were 4 deaths. One patient was pronounced in the OR after numerous attempts of short term support and IABP insertion as well as the usual chemical therapy. Total time on bypass was 545 minutes with total ischemic time totaling 321 minutes. This patient required extensive reconstruction of three arteries, two conventional grafts, and an aortic valve