
CASE REPORT

Normothermic Cardiopulmonary Bypass in the Larger Patient

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KEYWORDS: Normothermic; Cardiopulmonary bypass circuit; larger patient; secondary oxygenator.

Abstract

A 27-year-old male patient presented for elective arrhythmia surgery. Due to the nature of the surgical procedure, i.e. normothermic bypass, light anaesthetic, dislocation of the heart, etc., the physical size of this patient was of concern. The patient was 183 cm tall and weighed 141 kg. The calculated body surface area was 2.68 M₂ and the calculated flow was 6.7 LPM. Because of the increased oxygen demands that are possible during arrhythmia surgery, the ability of a single oxygenator to adequately transfer sufficient amounts of oxygen during all phases of the procedure was questioned. The decision was made to place two hollow fiber membrane oxygenators in line to prepare for the possibility of inadequate gas transfer. Both membranes were primed and de-aired as per our established protocol, after which the second membrane was isolated from the circuit. During the procedure our monitoring of serial blood gases and O₂ saturations demonstrated an oxygen deficit. The decision to utilize the second oxygenator was then made. The patient underwent a successful surgical ablation of a posteroseptal accessory pathway and was discontinued from cardiopulmonary bypass uneventfully.

Introduction

Surgical correction of cardiac arrhythmias (1), utilizing cardiopulmonary bypass (CPB) can present unique problems to the perfusionist. The ability to adequately oxy-

genate these patients can be compromised by a number of factors. These patients are often otherwise healthy individuals with a higher muscle-mass in proportion to body weight as compared to the patient with ischemic heart disease or valvular disease. In addition, the technique in our institution is to perform normothermic CPB for this specific operative procedure. Although the anaesthetist may aim for early arousal and extubation, the patient must be kept adequately paralyzed to minimize oxygen consumption. Also, the necessary manipulation of the heart during the dissection can cause varying degrees of impairment to venous return. In our experience, the retraction of the heart during the dissection is of major importance. This can cause low venous return necessitating a low arterial flow. All of these factors may result in a situation where oxygen demand exceeds oxygen supply. This may lead to a less than ideal perfusion. For these specific patients utilizing CPB our technique is to use inline oxygen saturation monitors to try to ensure adequate oxygenation (2). When the patient is of a larger than normal size and weight, all of the above factors may be exaggerated.

Case Report

In December 1987 a 27-year-old male presented to our institution with Wolf-Parkinson-White Syndrome (WPW). The patient had been diagnosed at age 17 when he experienced an episode of tachycardia. This was associated with extreme dizziness and he required two cardioversions in the emergency room. He was well until January of 1987 when he began having repeated episodes of ventricular tachycardia and was again seen in the emergency room on at least 7 occasions.

On examination the electrocardiogram showed a WPW pattern suggestive of a posteroseptal accessory pathway. The ECG submitted showed atrial fibrillation with a very

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rapid ventricular response conducting over a posteroseptal accessory pathway. The patient was admitted for electrophysiological (EP) assessment and possible surgical correction.

The EP study confirmed the diagnosis and due to the presence of the potentially life threatening arrhythmia, which was refractory to drug therapy, the decision was made to correct the problem surgically.

The patient was taken to the operating room and prepared for surgery. Because of his body size (141 kg, 183 cm) and greater than normal muscle mass, (former semi-pro football player) there was a concern about our ability to adequately perfuse this patient. After consultations with other members of the perfusion team, the anaesthetist, and the surgeon, the decision was made to prepare 2 membranes (Bentley BCM-7) (a) for use in the circuit. These membranes were both CO₂ flushed and primed and then the second membrane was clamped out of the extracorporeal circuit. After a routine median sternotomy, the diagnosis was confirmed with intraoperative electrophysiological mapping.

Forty thousand (40,000) units of heparin were administered through the central line with a resulting ACT of 631. The aorta was then cannulated with a 24 Fr. THI cannula (b), with bicaval cannulation of the SVC and the IVC with a 30 Fr. and 32 Fr. USCI cannulae (c).

The patient was placed on normothermic CPB with an initial pump flow of 5.5 LPM. Venous and arterial saturations were continuously monitored (Oxysat Bentley) (a) and blood samples drawn every 20 minutes for venous and arterial blood gas determinations, as well as for hematology, and electrolytes results. Twenty minutes into the procedure the arterial saturation dropped to 90.8%. This was caused by a low venous return due to the retraction of the heart with resulting low arterial flows, subsequently causing a decreased venous saturation. The second membrane was then included in the extracorporeal circuit and even though the venous saturation and flows demonstrated wide fluctuations, we were able to maintain arterial saturations of greater than 98%. Towards the end of the procedure the second membrane was isolated from the extracorporeal circuit and the patient maintained on a single membrane for the remaining 5 minutes of the surgical procedure. The patient was discontinued from CPB uneventfully and returned to the ICU. The remainder of his postoperative course was routine and a repeat EP study showed no evidence of an accessory pathway. He was discharged from the hospital on the eighth postoperative day on no medication.

a Bentley Laboratories Inc., Irvine, CA 92714

b Argyle Division of Sherwood Medical, St. Louis, MO 83103

c C.R. Bard Inc., Billerica, MA 01822

Cardiopulmonary Bypass Circuit

The cardiopulmonary bypass circuit consisted of 2 Bentley BCM-7 hollow fiber membrane oxygenators (surface area 5.8 sq meter each) connected in parallel (Figure 1). The integral venous reservoir and heat exchanger of the primary oxygenator was utilized with only the membrane compartment of the second oxygenator incorporated into the circuit. The venous return line of the circuit consisted of 1/2" by 3/32" tubing with the remainder of the circuit consisting of 3/8" by 3/32" tubing except for the 1/2" pump head. The 3/8" line was Y-ed off from the pump outlet into both the membrane inlets and then from the arterial outlet of both membrane outlets the line was Y-ed into the arterial return line which incorporated an arterial line filter (Intersept 20 micron (d)). An oxygen blender (Cobe) (e) was used for the primary membrane and a separate oxygen outlet and flowmeter used for the second membrane. Venous and arterial saturation were monitored with inline Oxysats (Bentley). The pump was a Cobe-Stockert (e).

Conduct of Perfusion

The CPB circuit and the 2 BCM-7 oxygenators were flushed with 100% carbon dioxide and primed with 3500 cc Lactated Ringers solution. Also included in the prime were 5,000 units of Heparin and 100 cc of Sodium Bicarbonate.

CPB was initiated with a gas flow of 9 LPM of 100% O₂ and 100 cc/min CO₂ through the primary oxygenator. The second membrane was isolated from the circuit with a clamp on the membrane inlet line and one on the membrane outlet line. At the beginning of the procedure the primary membrane proved adequate for the oxygen demands of the patient as measured by the arterial and

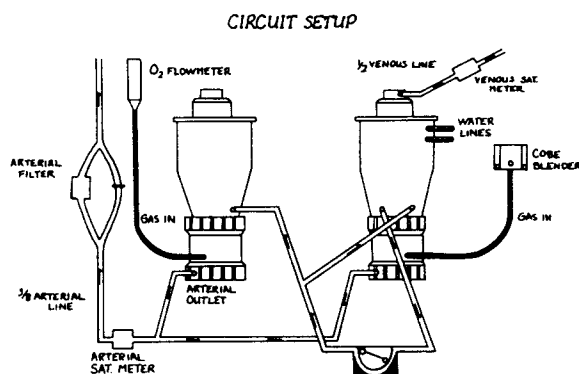


Figure 1. Circuit set-up—diagram of the circuit set-up with the second membrane incorporated into the circuit.

d Medtronic Inc., Minneapolis, MN 55432

e Cobe Laboratories Inc., Lakewood, CO 80215

venous O₂ saturations. Once the heart was retracted to perform the surgical dissection the flow was reduced to 4.1 LPM due to reduced venous return. The venous saturation fell to 53.3% and the arterial saturation to 90.8%. At this time the decision was made to utilize the second membrane which had been previously incorporated into the extracorporeal circuit. The clamps were removed from the membrane inlet line and the membrane outlet line. The second membrane was run with 3 LPM of 100% O₂. Immediately the arterial saturation returned to over 98% (Figure 2). Over the course of the procedure the arterial saturations remained at adequate levels even though the flows and the venous saturations varied due to changes in venous return. Toward the end of the surgical procedure, with the heart no longer dislocated, the second membrane was clamped out of the extracorporeal circuit again and the patient maintained adequately on the primary membrane. Normothermia was maintained utilizing the integral heat exchanger of only the primary oxygenator. CPB was discontinued after 85 minutes and decannulation was uneventful.

Discussion

To ensure adequate oxygenation and tissue perfusion during routine CPB is a fundamental requirement provided the cardiac surgical patient by the clinical perfusionist. There may be an anticipated difficulty in providing such oxygenation when the patient is presented at surgery with a larger than normal body mass in conjunction with a cardiac procedure that requires a normothermic perfusion. Previous authors (3,4) have reported a modified perfusion circuit used for a moderate hypothermic CPB procedure involving a large obese patient undergoing coronary artery bypass surgery.

In the case of this particular patient, other than the large muscle mass, the perfusion team was concerned with not only the depth of anaesthesia but also the degree of surgical manipulation required. Such manipulation and dislocation of the heart can cause a decrease in venous return to the oxygenator with resulting lower than acceptable flows. Further more, a simultaneous decrease in venous return to the beating heart can cause systemic hypotension resulting in lower than acceptable oxygen saturations and inadequate tissue perfusion.

When such a surgical situation is considered, the perfusionist must work in concert with the attending anaesthetist in formulating a plan to ensure adequate tissue perfusion through direct modification of both the perfusion circuit and the anaesthetic technique. Clinical studies performed at our institution have demonstrated a reduction in oxygen consumption during hypothermic CPB by as much as 25% when patient paralysis is adequately maintained during anaesthesia (5).

CARDIOPULMONARY BYPASS DATA SATURATIONS and FLOWS

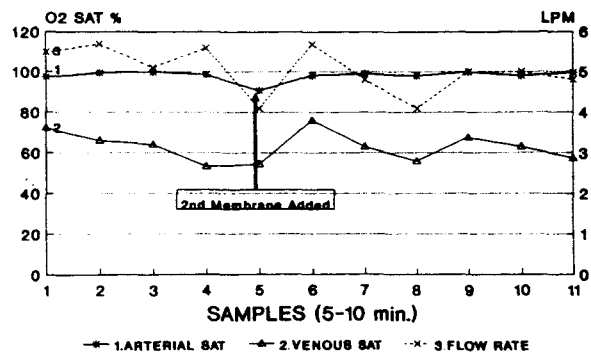


Figure 2. Graph plotting arterial and venous oxygen saturations and systemic flow rates.

A clinical situation has been demonstrated, whereby the oxygen demand of a patient did exceed the oxygen supply capabilities of a single oxygenator. Because this situation was anticipated, the immediate utilization of the incorporated secondary membrane resulted in our ability to reverse this undesirable trend. This resulted in adequate oxygenation as was demonstrated by serial blood gases and monitoring of extracorporeal venous and arterial oxygen saturations. When this clinical situation is presented to the perfusion team, a thorough pre-operative assessment, adequate monitoring of patients oxygenation status, and a review of the relevant literature should aid the perfusionist in providing such a large patient with satisfactory oxygenation and adequate tissue perfusion.

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