

**Case Report**

***Ultrafiltration / Hemodialysis During Cardiopulmonary Bypass:  
A Case Report***

Scott D. Niles, BA, Robin G. Sutton, MS, CCP, Richard P. Embrey, MD

University of Iowa Hospitals and Clinics, Iowa City, Iowa

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**ABSTRACT**

Patient demographics for elective cardiovascular surgery have shifted toward older patients with more profound disease states. Cardiopulmonary bypass is complicated when the patient presents with end stage renal disease. Hemodialysis during cardiopulmonary bypass has been successfully employed to reduce the postoperative sequelae associated with cardiopulmonary bypass. A patient with end stage renal disease who presented for coronary artery bypass grafting serves as the subject of this case report. Utilizing a modified technique previously described by Wiggins and Dearing, we describe successful intraoperative use of hemodialysis during cardiopulmonary bypass. Our experience suggests that hemodialysis during cardiopulmonary bypass is an effective alternative to ultrafiltration and may prolong the time interval for resumption of postoperative dialysis regimens.

Address correspondence to:  
Scott D. Niles  
University of Iowa Hospitals and Clinics  
Perfusion Technology Program  
Department of Surgery  
Division of Cardiothoracic Surgery  
1600 JCP  
Iowa City, IA 52242

## INTRODUCTION

Population demographics in patients undergoing elective cardiovascular surgery have undergone dramatic changes over the past twenty years. With a trend toward older patients with more profound disease states (1).

One such potential complication to cardiovascular surgery is the patient who presents with end stage renal disease. It has been reported that as many as half of the patients supported with chronic hemodialysis will die as a result of cardiovascular complications (2,3). As these patients become more widely evaluated for cardiopulmonary bypass procedures, the challenge to the perfusionist will be to facilitate postoperative recovery of these patients by normalizing existing electrolyte disturbances.

The use of intraoperative hemodialysis may be a useful adjunct in the treatment of patients with chronic renal failure by eliminating or limiting pre- and postoperative dialysis regimens and their associated risks (2,4). The following case study describes a modification of a technique previously described by Wiggins and Dearing to manage a patient who presented for cardiac revascularization, complicated by end stage renal disease (4).

## CASE DESCRIPTION

A forty-four year old Caucasian male with a 30 year history of Type I diabetes insipidus, peripheral vascular disease, hypercholesterolemia, hypertension, end stage renal disease, prior myocardial infarction, and status post percutaneous transluminal coronary angioplasty x 2, presented to the University of Iowa Hospitals for evaluation. Patient complaints included substernal chest pain, fatigue, and shortness of breath. After medical evaluation, the patient was scheduled for his fourth coronary angiography. Coronary catheterization revealed severe left anterior descending, left circumflex, and right coronary artery occlusions in excess of 95%. Ejection fraction at catheterization was found to be 43%.

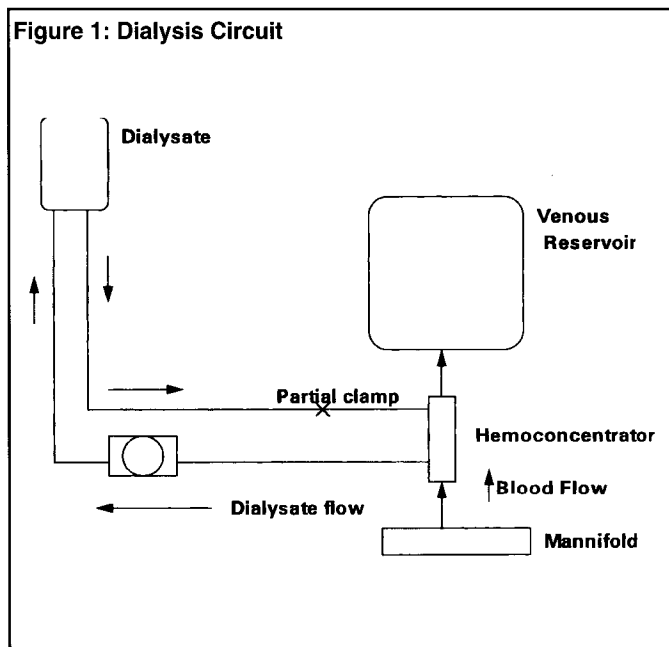
At the time of angiography the cardiology staff felt that the patient's prior disease state and unfavorable long term angioplasty results suggested surgical revascularization. The patient was referred to the cardiothoracic surgery service and scheduled for surgery. The patient was dialyzed one day prior to surgery. The following laboratory values were obtained on the day of surgery: platelet count 192,000/mm<sup>3</sup>, hemoglobin 8.6 g/dl, hematocrit 26%, sodium 132 meq/L, potassium 4.8 meq/L, blood urea nitrogen (BUN) 50 mg/dl, creatinine 6.5 mg/dl.

The surgical team concluded that hemodialysis during cardiopulmonary bypass may be more effective than conventional ultrafiltration in maintaining electrolyte balance while

helping to resolve elevated BUN and creatinine levels.

A hemodialysis circuit was constructed in parallel with the cardiopulmonary bypass circuit (Figure 1). A purge port on top of the arterial filter served as the blood source for an ultrafiltration hemoconcentrator<sup>a</sup> which then emptied into a venous reservoir bag. Dialysate circulated counter current to the blood flow, and a partial occluding clamp was placed on the negative pressure side of the pump, proximal to the hemoconcentrator, to increase transmembrane pressure. The dialysate chosen was Dianeal PD-2 with 2.5% dextrose.<sup>b</sup> The mixture contains sodium 132 meq/L, calcium 3.5 meq/L, magnesium 0.5 meq/L, chloride 96 meq/L, and lactate 40 meq/L. To this mixture, 2 meq/L of potassium chloride was added to avoid excess removal of serum potassium.

The anticipated dilutional hematocrit on bypass was predicted to be less than twenty percent, so two units of packed red cells were added to the pump prime. Heparin was administered at 300 units/kg and the patient was cannulated for bypass. After confirmation of activated coagulation times greater than 480 seconds, cardiopulmonary bypass was initiated without incident. After approximately two minutes of hemodynamic stabilization, dialysis of the patient was begun by utilizing an additional roller pump head (Stockert/Shiley)<sup>c</sup>. Dialyzer solution flows ranged from 500-600 ml/minute and blood flow shunt through the hemoconcentrator was estimated to be 600-700 ml/minute by momentarily interrupting blood flow through the hemoconcentrator, noting the patient mean arterial pressure, then reestablishing blood flow through the hemoconcentrator and adjusting patient arterial blood flow to a similar patient mean arterial pressure. Approximately 800 ml of dialysate was removed from each 2 liter bag prior to start of hemodialysis. This volume was removed to accommodate volume gained from ultrafiltration. Dialysate flow, counter current to blood flow, in combination with a partial occlusion clamp adjusted until gas was observed



a Bard Cardiopulmonary Model H4207, Tewksbury, MA 01876

b Dianeal PD-2, Baxter Healthcare Inc., Deerfield, IL 60015

c Sorin Biomedical, Irvine CA 92713

coming out of solution, afforded the opportunity to remove excess plasma water by ultrafiltration.

Intermittent cold blood cardioplegia was administered at a 2 : 1 ratio utilizing both antegrade and retrograde delivery techniques. A total dose of 32 meq potassium chloride was utilized to initiate and maintain cardiac arrest. Administration of an additional three units of packed red blood cells was also necessary during the course of cardiopulmonary bypass to maintain an adequate hematocrit. Blood flows were kept between 2.4 and 2.8 L/min/m<sup>2</sup>, and the patient's mean arterial blood pressure on pump was greater than 60 mmHg. The dialysate solution was changed after one hour of cardiopulmonary bypass to allow for further removal of plasma water by ultrafiltration and to facilitate ionic exchange between dialysate and patient blood. Total ultrafiltrated volume removed during the procedure was 1600 ml and the hematocrit at the termination of bypass was 30%. Patient temperature on bypass was allowed to drift to a core temperature of 29 degrees Celsius.

After successful revascularization of seven coronary arteries, the patient was rewarmed to 37°C. Prior to the termination of bypass, blood samples were sent to the laboratory. The results were as follows: sodium 131 meq/L, potassium 5.1 meq/L, chloride 96 meq/L, blood urea nitrogen 20 mg/dl, and creatinine 3.4 mg/dl.

The patient was successfully weaned from cardiopulmonary bypass and protamine sulfate was administered for heparin reversal. The patient's postoperative recovery was uneventful and the patient was discharged on postoperative day 8. The patient resumed his twice weekly dialysis regimen three days postoperatively.

## DISCUSSION

End stage renal disease presents a significant problem to the patient undergoing cardiopulmonary bypass procedures. Typically, these patients present as fluid challenged and anemic, often requiring homologous blood transfusions intraoperatively to maintain adequate hematocrits. Blood product administration, in combination with the effects of high potassium cardioplegia solutions, can exacerbate existing renal metabolite retention conditions. Hemodilutional effects and electrolyte imbalances must be carefully monitored and normalized perioperatively to reduce postoperative sequelae associated with cardiopulmonary bypass. Hemodialysis during cardiopulmonary bypass is an effective alternative to ultrafiltration alone. Dialysate ionic composition can be modified according to the patient's needs, rendering it more effective than ultrafiltration alone. The technique we describe incorporates both aspects of ultrafiltration and hemodialysis to maximize the patient's hematocrit level and to balance electrolyte composition.

Systemic heparinization for dialysis in the immediate postoperative period exposes these patients to hypotensive episodes, and the risk of increased bleeding complications. We

believe that intraoperative hemodialysis can be used successfully on patients with end stage renal disease and may postpone resumption of postoperative dialysis regimens.

## REFERENCES

1. Cheitlin MD, Sokolow M, McIlroy MB. *Clinical Cardiology*. Norwalk: Appleton and Lange; 1993: 225.
2. Kirby D, Applegate B, Gabrhel W. et al. Renal dialysis during coronary artery revascularization: A case study. *J Extra-Corpor Technol*. 1982; 14: 424-27.
3. Wilson K, Kreiger K, Isom O. Cardiopulmonary bypass procedures in dialysis patients. *Ann Thorac Surg*. 1993; 55: 667-84.
4. Wiggins D, Dearing J. Simultaneous cardiopulmonary bypass and dialysis. *J Extra-Corpor Technol*. 1985; 17: 117-20.