CASE REPORT

Renal Dialysis during Coronary Artery Revascularization: A Case Study

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Abstract

A diabetic, uremic patient maintained on chronic hemodialysis underwent coronary artery revascularization with successful intraoperative dialysis. A portable sorbent dialyzer and hollow fiber artificial kidney were used in conjunction with the extracorporeal heart pump and oxygenator to dialyze the patient's blood during cardiopulmonary bypass. Conservative fluid management and use of isotonic solution with dialyzable solutes prevented fluid imbalances. Cold cardioplegia without potassium combined with core hypothermia (26°C) protected the myocardium while minimizing the risk of hyperkalemia. Alterations in the serum potassium level were adjusted with changes in the infusate bath of the dialyzer during bypass-dialysis. Intraoperative dialysis in this case optimized chemistries and fluid balance and prevented the hazards of hemodialysis during the immediate post-operative period when bleeding and hypotension could limit effectiveness and jeopardize the patient's condition.

Introduction

In the field of extracorporeal technology, the perfusionist is often confronted with difficult and complex patient situations. One such case is the patient maintained on hemodialysis prior to coronary artery revascularization.

Over half the patients supported with chronic hemodialysis die as a result of cardiovascular complications[1]. Factors complicating survival are pericarditis and bacterial endocarditis. Both entities are recognized as secondary sequelae of uremia. Bacterial endocarditis is also notable as an extreme complication of chronic hemodialysis. Although complication rates are high, current literature indicates that coronary artery bypass is successfully performed on patients with long-term renal dysfunction[2-4]. Use of intraoperative dialysis has facilitated management of the uremic patient during aortic valve replacement[5]. Presented here is a simple method for managing the hemodialysis patient intraoperatively during cardiopulmonary bypass.

Case Study

A 48-year-old Mexican female was admitted for evaluation and treatment of an acute incident of coronary insufficiency. In addition to experiencing unstable angina and adult-onset diabetes mellitus, she had been on chronic hemodialysis for five and one-half years. The origin of her renal failure was suspected as a secondary complication of recurrent urinary tract infections, diabetic glomerulosclerosis, and chronic pyelonephritis. Her angina had worsened recently and was occurring two or three times a week, most often during physical or emotional stress. She sustained an inferior wall myocardial infarction six months prior to this admission.

Past surgical history was extensive and included an unsuccessful cadaveric renal transplant which

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failed three months post-operatively. Since initiation of her dialysis, she exhibited hypertension, primarily fluid-related.

Physical assessment revealed multiple problems, including wide-spread peripheral vascular disease, diminished peripheral pulses, and bilateral carotid bruits. There was diffuse edema, bibasilar rales, and signs of definite fluid overload on the admission chest x-ray. Hemoglobin was 10.9 gm/100 ml on admission; white blood cell count and cardiac enzymes were not elevated; fasting blood sugar was 299 mg/dl; blood urea nitrogen, 60 mg/dl; creatinine, 13 mg/dl; and potassium, 6.0 mEq/L.

Cardiac catheterization and angiocardiography revealed high-grade lesions in the middle third of the right coronary artery, prior to the bifurcation of the posterior descending coronary artery and the atrioventricular nodal branch, and in the proximal left anterior descending, proximal circumflex, and in each of the obtuse marginal coronary arteries. Left ventriculogram was normal and the left ventricular end-diastolic pressure was 12 mm Hg.

To correct fluid overload and blood chemistries, the patient was dialyzed daily for three days preoperatively. The patient was also hypertransfused to a hemoglobin of 14.7 gm/dl to prepare for surgery and minimize post-operative anemia.

On the morning of surgery, however, she again presented with an elevated potassium of 6.0 mEq/L, and preparation for dialysis during cardiopulmonary bypass was initiated.

Procedure

Anesthesia included sodium pentothal, diazepam, fentanyl, lorazepam, oxygen, and ethrane. The operative procedure consisted of saphenous vein grafting to the distal segments of the left anterior descending, obtuse marginal, and right coronary arteries.

A portable REDY or Sorbsystem dialyzer[a] with a Cordis-Dow 1.8 capillary hollow fiber kidney[b] was used in conjunction with a Sarns 500 heart pump[c] and a Shiley 100A disposable bubble oxygenator[d]. The Sorbsystem control unit is a sorbent dialysis delivery system using a five-layer cartridge of chemicals to purify dialysate. Dialyzers designed for negative pressure ultrafiltration (hollow fiber kidneys, as used in this case) are connected to the external ports on the Sorbsystem control unit. Ultrafiltration pressures can be varied from 0–500 mm Hg. An infusate system in the dialyzer is used to add calcium, magnesium, and potassium acetate to the dialysate according to patient needs.

This method of conducting dialysis during surgery was technically simple with the incorporation of in-line dialysis. By combining the artificial kidney and oxygenator, only two connections were needed (see Figure 1). The arterial line of the kidney was attached to the site of the arterial sampling port of the arterial reservoir. No modifications to these sites were required as the leurlok adaptors were compatible. The oxygenated blood was then delivered to the dialyzer for purification via roller pump and through a one-way bubble-trap valve. The blood was returned through the venous line of the kidney which was attached to the rapid prime port on the oxygenator. This attachment allowed arterialized blood to be returned without reoxygenation.

Priming solutions for the extracorporeal circuit included 500 ml of 5% albumin, 500 ml packed red blood cells, and 500 ml 0.9% sodium chloride. During perfusion blood gas, electrolyte, complete blood count, and blood glucose levels were monitored to assure effective perfusion and monitor electrolyte levels. No potassium was added to the infusate bath of the dialyzer until the potassium dropped to 2.8 meq/L. This occurred forty minutes after the initiation of bypass-dialysis. A 4% potassium bath was then used in the dialyzer. After fifteen minutes exposure to this solution, the patient's potassium level was 3.9 meq/L. The potassium was then removed from the dialyzer and the potassium level remained stable at 3.9 meq/L until the end of surgery.

To conduct dialysis with cardiopulmonary bypass, a total of 450 mm Hg transmembrane presssure was used. This transmembrane pressure was a combination of 100 mm Hg positive pressure from the Sorbystems dialysate pump (pushing

[a] Organon Teknika Corp., Oklahoma City, OK 73119

[b] Cordis-Dow, Miami, FL, 33145

[c] Sarns Inc., Ann Arbor, MI 48103

[d] Shiley Inc., Irvine, CA 92713

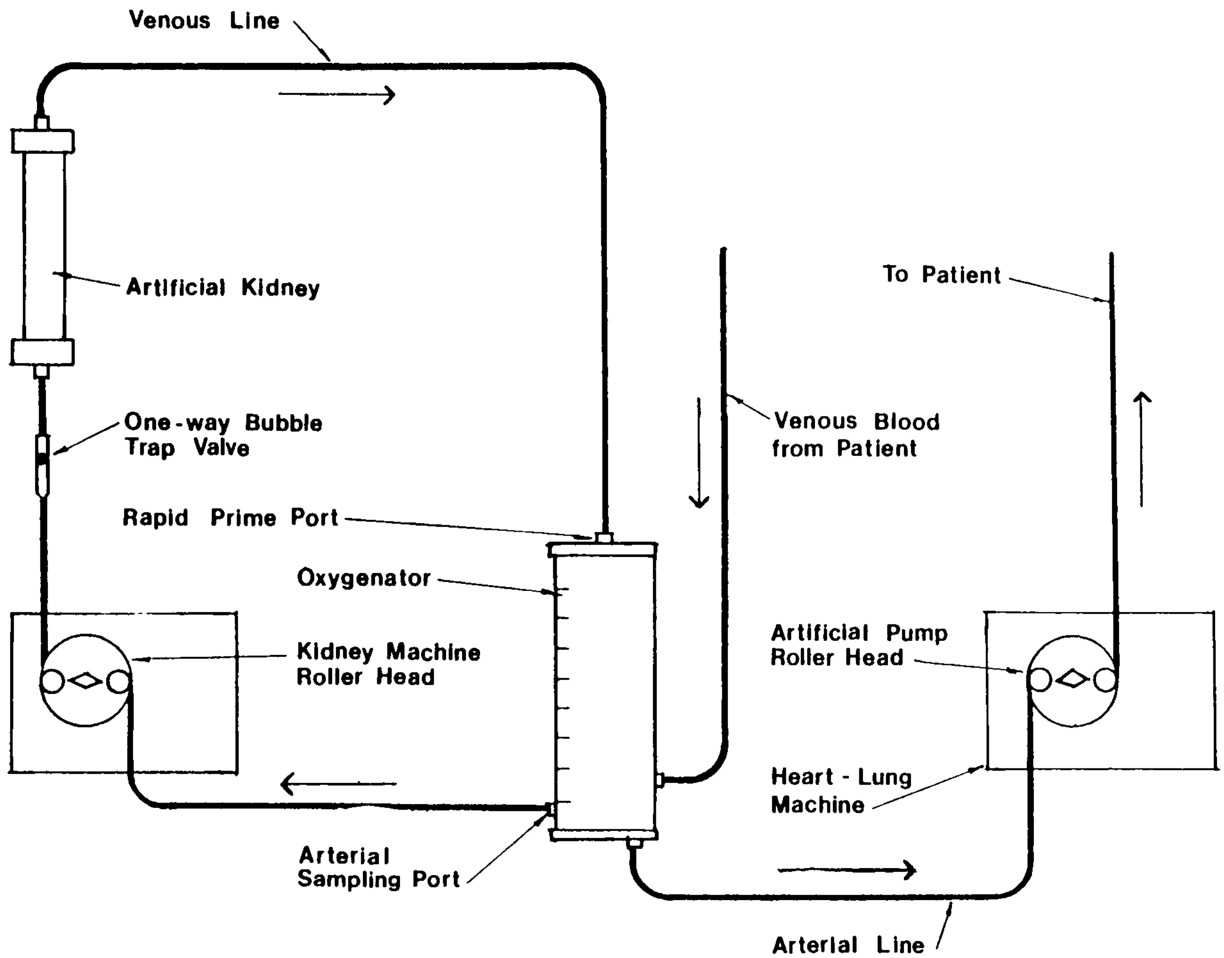

FIGURE 1. Diagram of Bypass-Dialysis Circuit.

fluid through the membranes of the artificial kidney) and 350 mm Hg negative pressure (pulling fluid through the kidney).

During surgery the patient's core temperature was lowered to 26°C and myocardial protection was insured with aortic root infusion of 4°C potassium-free crystalloid cardioplegia solution. Myocardial temperature was maintained in the range of 8–12°C.

During extracorporeal circulation, the patient was anticoagulated with heparin, using 300–500 u/Kg and the protocol outlined by Bull et al[6]. This increased the activated clotting time to 480 seconds, well above that required for dialysis alone (180 seconds).The heparin activity was then reversed with protamine using the same protocol[6].

Cardiopulmonary bypass was maintained with continuous hemodialysis for two hours and 22 minutes. During this time 1500 ml of fluid were removed and the potassium was lowered to 3.9 meq/L. While on bypass, as little solution as possible was administered intravenously and through the extracorporeal circuit. An additional 1000 ml of 0.9% sodium chloride was used to maintain optimal fluid levels in the extracorporeal circuit as fluid was removed with dialysis.

Upon restoration of cardiac function, bypass-dialysis was discontinued. After closure of the median sternotomy and leg incisions, the patient was transferred to Intensive Care in stable condition. Dialysis was not needed until two days after surgery as a result of effective intraoperative techniques. After an uneventful post-operative course, the patient was discharged with no recurrence of her angina, and she continued her regime of dialysis twice weekly.

Discussion

Fluid and electrolyte balance is critical in all stages of the surgical care of the dialysis patient. Renal dysfunction necessitates careful monitoring to prevent the hazards of hypervolemia and hyperkalemia. Selection of prime solutions with dialyzable solutes that do not add to the free water load of the patient prevents imbalances. Serum potassium, calcium, magnesium and acetate levels can easily be controlled with changes in the concentrations of the infusate of the dialyzer as accomplished in this case.

Intraoperative dialysis in this patient provided an excellent alternative to post-operative techniques. Hemodialysis in the immediate post-operative period is difficult on a patient with compromised cardiac function and uremic coagulopathies. Hypotension and bleeding usually limit the effectiveness of such procedures[3]. Intraoperative dialysis eliminates the need for postoperative heparinization and prevents a positive fluid balance. Such overload is poorly tolerated in this type of patient and can be prevented with concommitant bypass-dialysis as described in this study.

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