Coronary Revascularization in Patients Maintained on Chronic Hemodialysis

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SUMMARY Thirty-two thousand patients are presently maintained in chronic dialysis programs. Cardiovascular complications have been shown to be responsible for 50 to 65% of the deaths in such patients. Despite this and the increasingly frequent use of coronary bypass surgery in the general population, only two patients have previously been reported to have successfully undergone coronary bypass surgery while maintained on chronic hemodialysis. This paper reports two additional such patients who successfully underwent coronary revascularization without difficulty. Pertinent details of preoperative, intraoperative, and postoperative management are outlined for these patients and the 13 chronic dialysis patients who have had cardiopulmonary bypass for other reasons. With careful planning, coronary revascularization can be successfully carried out in this group of patients with minimally increased operative risk.

THIRTY-TWO THOUSAND PATIENTS are presently maintained in chronic dialysis programs and an estimated 10–15,000 will be added each year.² Fifty to sixty-five percent of the deaths occurring in such patients are due to cardiovascular complications.²,⁴ Pericarditis has long been recognized as a complication of uremia and the appropriate treatment of uremic pericardial tamponade has been controversial.⁶,⁷ Bacterial endocarditis has also been noted to be a severe complication of repeated hemodialysis and 12 such patients have been treated by valve replacement.⁸–¹⁴ Despite the known incidence of coronary disease in dialysis patients and the popularity of coronary bypass procedures, there are only two reports in the literature of coronary artery bypass surgery performed successfully in patients on chronic hemodialysis.¹⁵,¹⁶ Whether such surgery should be offered to these patients is becoming an increasing problem. We herein report our experience with two such patients and review the other two reported cases in the literature. In addition, the pertinent details of the other 13 patients on chronic dialysis (12 valve replacement, 1 pericardectomy) who have undergone cardiopulmonary bypass will be reviewed (table 1).

Case Reports

Case 1

L.J., a 50-year-old white male, was known to be diabetic (controlled by diet) and hypertensive for ten years, and to have a nine year history of typical angina which had been controlled with nitroglycerin and propranolol. Four years prior to admission, his angina increased and he was forced to retire. Ten weeks prior to admission, he noted significant increase in chest pain including angina decubitus. He was referred for evaluation and was found at that time to be in chronic renal failure. Chronic hemodialysis was started at that time, six weeks prior to this admission. In the interval between initiation of hemodialysis and this admission, the angina continued to increase. He did not smoke. On admission, physical examination was within normal limits and blood pressure was 110/70 mm Hg. Laboratory work included a creatinine of 9.1 mg/100cc, BUN of 110 mg/100cc, hematocrit of 28% and cholesterol of 242 mg/100cc. Cardiac catheterization demonstrated a left ventricular pressure of 125/14–15 mm Hg, and a dilated but reasonably well contracting left ventricle. Coronary angiograms revealed 50% occlusion of the left main coronary artery with a 90% occlusion of the proximal left anterior descending after the first septal perforator and a 90% occlusion of the first marginal branch of the circumflex. The right coronary artery was totally occluded.

Because of his symptoms and the significant nature of his lesions, it was felt that he should undergo coronary artery bypass surgery. He underwent prolonged hemodialysis on the evening prior to surgery and then on March 26, 1976, underwent saphenous vein aortocoronary bypass grafts to the left anterior descending, to the first marginal branch of the circumflex, and to the distal right coronary artery. Anesthesia was induced with morphine, oxygen, and pentothal and maintained with halothane. Cardiopulmonary bypass was achieved with a disposable bubble oxygenator (Bentley) primed with 1500 cc of blood and 1000 cc of electrolyte solution. Total pump time was 150 min. No significant bleeding difficulties were encountered and the patient required 1000 cc of blood postoperatively.

The patient had an uneventful postoperative course. He was extubated on the first postoperative day and hemodialysis was begun on the third postoperative day. He had no difficulty with his arterio-venous fistula and was discharged subsequently on the eleventh postoperative day. He has continued to do well at home on no medications, has had no further chest pain, and has subsequently undertaken home hemodialysis training and is dialyzing himself.

Case 2

S.J. is a 50-year-old white male with chronic renal failure secondary to chronic glomerulonephritis who had been on home hemodialysis for six years. He had a seven year history of typical angina pectoris which was stable and well controlled by nitroglycerin. Three weeks prior to admission, he had a marked increase in his symptoms. He noted particularly that his symptoms increased on the evening just prior

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*The operation of L.J. was performed by Dr. Jefferson Hollingsworth, Jackson, Mississippi.
to his regular scheduled dialysis. On the day of admission he had the onset of chest pain during hemodialysis. An electrocardiogram at that time revealed depressed ST segments in leads I, aV_{L}, and V_{5,6}. He was admitted to the hospital and started on propranolol 10 mg q.i.d. Physical examination was unremarkable. Laboratory work included a creatinine of 16.5 mg/100cc, BUN of 80 mg/100cc, cholesterol of 327 mg/100cc, and total triglycerides of 436 mg/100cc. A repeat resting electrocardiogram revealed only nonspecific ST-T abnormalities.

Following admission and initiation of propranolol therapy, his pain disappeared. However, because of his history and because of the documented abnormal electrocardiogram during an episode of chest pain, he underwent cardiac catheterization. The left ventricular pressure was 160/8-10 mm Hg with an ejection fraction of 0.5. Diffuse left ventricular hypokinesia was demonstrated. Coronary arteriograms revealed a 90% occlusion of the left main coronary artery followed by total occlusion of the left anterior descending. There was a 95% occlusion of the proximal right coronary artery.

The patient's severe symptoms and angiographic findings prompted coronary artery bypass. A prolonged dialysis was carried out the day prior to surgery in order to achieve optimal fluid and electrolyte balance. Toward the end of hemodialysis he suddenly became less responsive and had no measurable blood pressure. A rapid infusion of saline promptly restored blood pressure and mental status. Despite the fact that his electrocardiogram was unchanged, it was felt that he should be observed for several days and cardiac isoenzymes measured to rule out the possibility of myocardial infarction. No evidence of infarction, either by electrocardiogram or by cardiac isoenzymes, was subsequently demonstrated.

Accordingly, he was rescheduled for surgery and again hemodialysis was carried out on the evening prior to surgery. Aortocoronary saphenous vein grafts were placed to the left anterior descending, to the first diagonal branch of the left anterior descending, to the first marginal branch of the circumflex, and to the posterior descending branch of the right coronary artery. Anesthesia was induced and maintained with halothane, nitrous oxide, and oxygen and cardiopulmonary bypass was carried out using a disposable bubble oxygenator (Harvey) primed with 2000 cc of blood and 1000 cc of electrolyte solution. Total bypass time was 180 min. The patient was removed from cardiopulmonary bypass without any difficulty.

In the initial postoperative course he was hypertensive but this was controlled with an infusion of sodium nitroprusside. No bleeding difficulties were encountered and the patient required only 250 cc of packed cells postoperatively. The initial postoperative hematocrit reading was 38% and potassium was 4.2 mEq/L. He was extubated three hours postoperatively and chest tubes were removed approximately 12 hours later. On the second postoperative day, he received Kayexalate prophylactically and was dialyzed for the first time on the third postoperative day. The remainder of his postoperative course was complicated only by thrombosis of his Scribner shunt at the time of the initial postoperative dialysis and ultimately required revision. He had no further difficulties and was discharged on the tenth postoperative day. He has continued to do well at home on no medications and has had no further chest pain.

**Discussion**

Chronic pericarditis with tamponade, bacterial endocarditis, and coronary artery disease as manifested by angina pectoris are all recognized complications of long term hemodialysis. Although there is not uniform agreement, chronic pericardial tamponade is perhaps best managed surgically and does not require cardiopulmonary bypass.\(^4,5\) Bacterial endocarditis, while uncommon, does occur and may necessitate valve replacement. Lansing in 1968 was the first to carry out aortic valve replacement under such circumstances and to demonstrate that cardiopulmonary bypass could be performed successfully in patients maintained on

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**Table 1. Chronic Hemodialysis Patients Undergoing Operations Requiring Cardiopulmonary Bypass**

<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Age</th>
<th>Sex</th>
<th>Dx</th>
<th>Procedure</th>
<th>Outcome</th>
<th>Prime</th>
<th>Postop Injection</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lansing</td>
<td>1968</td>
<td>26</td>
<td>M</td>
<td>SBE, AI</td>
<td>AVR</td>
<td>Lived</td>
<td>---</td>
<td>PD</td>
<td>HD Pleural effusion</td>
</tr>
<tr>
<td>Ribot</td>
<td>1971</td>
<td>33</td>
<td>F</td>
<td>SBE, MI</td>
<td>MVR</td>
<td>Lived</td>
<td>H</td>
<td>PD</td>
<td>None</td>
</tr>
<tr>
<td>Manhas</td>
<td>1972</td>
<td>42</td>
<td>M</td>
<td>AI</td>
<td>AVR</td>
<td>Lived</td>
<td>MH</td>
<td>PD</td>
<td>None</td>
</tr>
<tr>
<td>Haimov</td>
<td>1974</td>
<td></td>
<td></td>
<td>ABE, AI</td>
<td>AVR</td>
<td>Lived</td>
<td>---</td>
<td>---</td>
<td>Bleeding</td>
</tr>
<tr>
<td>Sakurai</td>
<td>1974</td>
<td>52</td>
<td>M</td>
<td>CAD</td>
<td>CAGB</td>
<td>Lived</td>
<td>MH</td>
<td>HD</td>
<td>Resp. insufficiency</td>
</tr>
<tr>
<td>Posner</td>
<td>1975</td>
<td>19</td>
<td>M</td>
<td>AI</td>
<td>AVR</td>
<td>Lived</td>
<td>MH</td>
<td>HD</td>
<td>None</td>
</tr>
<tr>
<td>Wilcox</td>
<td>1975</td>
<td>30</td>
<td>F</td>
<td>SBE, AI</td>
<td>AVR</td>
<td>Lived</td>
<td>H</td>
<td>HD</td>
<td>None</td>
</tr>
<tr>
<td>Lambert</td>
<td>1975</td>
<td>31</td>
<td>F</td>
<td>AI</td>
<td>AVR</td>
<td>Lived</td>
<td>H</td>
<td>HD</td>
<td>None</td>
</tr>
<tr>
<td>Lansing</td>
<td>1976</td>
<td>52</td>
<td>M</td>
<td>CAD</td>
<td>CAGB</td>
<td>Lived</td>
<td>H</td>
<td>PD</td>
<td>None</td>
</tr>
<tr>
<td>Crawford</td>
<td>1977</td>
<td>50</td>
<td>M</td>
<td>CAD</td>
<td>CAGB</td>
<td>Lived</td>
<td>MH</td>
<td>HD</td>
<td>None</td>
</tr>
</tbody>
</table>

Abbreviations: H = hemodialysis; MH = modified hemodialysis; PD = peritoneal dialysis; HD = hemodialysis; SBE = subacute bacterial endocarditis; ABE = acute bacterial endocarditis; AI = aortic insufficiency; MI = mitral insufficiency; CAD = coronary artery disease; AVR = aortic valve replacement; AV = aortic valve; MVR = mitral valve replacement; CAGB = coronary artery bypass graft.
chronic dialysis. Since then, 10 of 12 reported patients have been managed successfully by valve replacement.\(^6\)\(^{-14}\)

Of these three complications, coronary artery disease is potentially the most severe and most frequently encountered. As noted, 50–65% of chronic hemodialysis patients die as the result of coronary atherosclerosis.\(^2\)\(^{-4}\) Long-term hemodialysis and renal transplantation may not only fail to prevent cardiovascular complications, but even accelerate them.\(^6\) Elevated triglycerides, vascular calcification due to secondary hyperparathyroidism, and hypertension may be contributing factors.\(^5\) The end result is that a significant number of otherwise well compensated dialysis and transplant patients may be totally disabled or may die prematurely because of coronary disease.

Sakurai in October 1973 performed successfully a two-vessel aortocoronary bypass graft in a 52-year-old man with chronic renal failure and accelerated angina.\(^16\) Several months later, Lansing followed with a two vessel coronary bypass in another 52-year-old man with accelerated angina.\(^16\) Sakurai stated that "this operation should be reserved only for those patients with intractable angina pectoris with good ventricular function who have been rehabilitated by dialysis and whose life style justifies the risk of operation."\(^16\) Lansing stated, "if the patient has a reasonable life expectancy with dialysis, but if survival or enjoyment of life is threatened by a correctable surgical condition, we believe that operation should always be seriously considered."\(^16\)

Clearly, patient selection is crucial. Although we believe it has now been adequately demonstrated that cardiopulmonary bypass can be performed safely in this group, coronary artery revascularization should probably still be limited to those patients who are well compensated on dialysis, who are severely limited by angina pectoris which is refractory to medical management, or whose anatomy as defined by coronary arteriograms places them in a "high risk" group. For example, our second patient had severe left main coronary artery stenosis and a right coronary lesion, and similar patients without renal failure have been demonstrated to have increased longevity following successful revascularization.\(^17\)\(^,\)\(^18\) Unfortunately, coronary bypass surgery will have no effect on the factors which cause the increased incidence of coronary artery disease in this group and long term follow-up may well demonstrate a decreased graft patency in them as compared to other groups.

It is generally agreed that these patients should be vigorously diazylized prior to surgery to obtain optimal fluid and electrolyte balance. One should be alerted to rapid shifts in intravascular volume which occur during dialysis and which can result in severe hyper- or hypotension. Either may be fatal in a patient with a critical coronary stenosis.

While some prefer to initiate postoperative dialysis with the peritoneal approach in order to avoid anticoagulation (table 1),\(^4\)\(^,\)\(^10\)\(^,\)\(^16\) others believe that hemodialysis can be carried out in the postoperative period without difficulty.\(^11\)\(^,\)\(^13\)\(^,\)\(^18\) By carefully monitoring postoperative fluid administration, restricting potassium administration, and using prophylactic heparin, we were able to wait until the third postoperative day to resume hemodialysis. This delay in no way compromised these patients and dialysis could have been carried out earlier or postponed further as the situation dictated. Initiation of dialysis in the postoperative period will obviously depend on the individual patient, his fluid status, and potassium level.

Others have noted difficulty with dialysis access routes in the operative and postoperative period.\(^5\)\(^,\)\(^12\)\(^,\)\(^19\) and we had this difficulty in one patient who required shunt revision. Shunt occlusion may be related to hypotension, low flow states, heparin/protamine administration, or failure to properly protect the extremity and shunt during the operation and postoperative period.\(^17\) Since dialysis access roots are finite in number, they should be protected carefully. This includes careful positioning and padding of the extremity and perhaps heparin infusion into the shunt as suggested by Lambert.\(^5\)

A variety of anesthetic agents have been used in the reported patients. Halothane has been successful in a number of earlier patients and was used in our two. Anesthetic considerations have been reviewed by Posner.\(^12\)

Most authors have preferred hemodilution techniques for cardiopulmonary bypass (table I). Several authors have pointed out the possibilities of sensitization by blood transfusion in these potential transplant recipients.\(^11\)\(^,\)\(^20\) However, this conclusion has been questioned and it would appear that it has not been satisfactorily resolved.\(^21\) This particular problem did not play a role in our two patients since neither was a transplant candidate. Others prefer hemodilution because they feel that it tends to decrease the chance of coagulation difficulties in these uremic patients.\(^5\)

Although we routinely use hemodilution, we chose to modify our technique in these two patients. In patients with coronary disease, we attempt to maintain relatively high flow rates and perfusion pressures during cardiopulmonary bypass in order to maintain distal coronary perfusion.\(^22\) In order to do this during long perfusions, it has frequently been necessary to add considerable additional volume to the circuit. At the end of the procedure, the hematocrit is relatively low, but this is usually easily corrected by diuresis and administration of the packed cells remaining in the pump. Since these uremic patients come to the operating room anemic and since diuresis is impossible, we felt the patient might remain more stable during bypass if less hemodilution were employed. This proved to be the case with very little additional volume required during bypass. At the end of the procedure, the hematocrits were 38% and 36%. Postoperative bleeding was not a problem in either patient and a minimal amount of blood was required postoperatively. It would appear that either hemodilution or our technique, which is essentially a whole blood prime, can be safely employed. If more blood is used in the prime, then it should be as fresh as possible in order to keep potassium levels as low as possible and to minimize hemolysis during bypass. We have also routinely employed autologous transfusion, but did not in either of these patients because of their relative instability during induction of anesthesia.

With the increasing numbers of people maintained on dialysis and with their known increased incidence of coronary disease, the problem of coronary revascularization in them will arise more frequently. While bypass surgery should remain relatively restricted at present, it is likely that as others demonstrate its safety, it will be more frequently performed.
References


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