Concurrent Dialysis During Cardiopulmonary Bypass

Charlene H. Rohrer and Mary Hartley Winkler
Donald N. Sharp Cardiac Center
San Diego, CA

Abstract

A series of cardiac surgical patients with acute or chronic renal failure, who required renal dialysis during cardiopulmonary bypass (CPB) is presented. The mean decrease in the creatinine levels during CPB with dialysis was 1.7 mg/dl. The pre-bypass range was 3.0 - 6.8 mg/dl and the post-bypass range was 1.9 - 3.9 mg/dl. All patients were successfully weaned from cardiopulmonary bypass. A significant decrease in the Blood Urea Nitrogen (BUN) and creatinine levels were observed in all patients. Metabolic and electrolyte derangements were corrected when encountered. Dialysis was not required in the immediate postoperative period for any of the patients in this series. The hemodynamic instability often encountered with dialysis was eliminated by utilizing concurrent dialysis during CPB. This proved to be a safe and effective method for treatment of the cardiac surgical patient in renal failure.

Introduction

Hemodialysis is currently utilized to sustain the lives of approximately 50,000 patients in the United States at this time.[1] The fact that these dialysis patients can also tolerate cardiac surgery is well documented.[1,2,4,5,9] The problems these patients have presented, have been dealt with by

TABLE 1
Patient Data

PATIENT	AGE	SURGERY	RENAL STATUS
1. Male	69	Single CABG & Reconstruction of the Mitral & Tricuspid Valves	Acute
2. Male	58	Resection of Left Ventricular Aneurysm & Closure VSD	Acute
3. Male	76	Triple CABG	Acute
4. Male	77	AVR & Single CABG	Acute
5. Male	73	Closure VSD & Single CABG	Acute
6. Male	77	AVR & Quintruple CABG	Acute
7. Male	66	Quintruple CABG	Chronic
8. Male	80	Closure VSD & Quadruple CABG	Acute

Direct communications to: Charlene H. Rohrer, B.S., C.C.P., Cardiovascular Perfusion Inc., 4219 Rueda Dr., San Diego, CA 92124
Presented at AMSECT's 21st International Conference, New Orleans, LA, April 11-13, 1983.

various methods. Recently, one of the protocols has been to perform hemodialysis during cardiopulmonary bypass.[3,6]

At Sharp Cardiac Center in San Diego, concurrent hemodialysis during cardiopulmonary bypass have been performed since April 1, 1981. One patient was on chronic dialysis prior to surgery. The remaining seven patients presented to surgery in acute renal failure due to decreased cardiac outputs. (Table 1). Already compromised by renal failure, they were then subjected to nephrotoxic dyes at cardiac catheterization. All were unstable hemodynamically and required surgery within 24 to 48 hours. Due to their hemodynamic status, recent insult of nephrotoxins, and deteriorating renal status, it was decided to perform hemodialysis concurrently with cardiopulmonary bypass. This afforded the benefits of dialysis, without risking the already unstable hemodynamic status of these patients.

Methods

The cardiopulmonary bypass circuit consisted of a bubble oxygenator, a filtered cardiotomy reservoir, an arterial line filter, and a heart-lung machine. A dialysis machine with a hollow fiber artificial kidney composed the dialysis circuit.

The extracorporeal circuit was primed with 1400 to 2000 cc of Plasmalyte 148[a] and 10,000 USP of beef lung Heparin. Some perfusionists also added 20 gm Mannitol and 25 gm Albumin. Bank blood was added as needed to maintain a hematocrit above 20%.

The dialysis circuit was primed with normal saline. The dialysis bath was either an acetate or bicarbonate bath with a potassium level of 4.0 - 4.5 mEq/L. The dialysis circuit was connected to the cardiopulmonary circuit by inserting the intake of the dialysis circuit into the venous sampling port. The return line was attached to either the cardiotomy reservoir or the top of the oxygenator.

The patients were anesthetized, heparinized, and cannulated in the usual manner. Cardiopulmonary bypass was instituted and stabilized. Hemodialysis was then begun. The patients were dialyzed with maximum ultrafiltration. The dialysis blood flow rates were 200 - 600 cc/minute with dialysate flows of 400 - 800 cc/minute. During cardiopulmonary bypass, the patient's blood pressure was maintained between 53 - 100 mmHg (m = 69.1) to afford an adequate perfusion pressure to the kidneys. The blood flow rate was maintained as conditions dictated, but were usually at 2.4L/min/m^2. Blood gases, hematocrit, platelet counts, sodium, and potassium levels were monitored every thirty minutes during the perfusion. Blood was added if volume was required and if the hematocrit was less than 20%. Otherwise, crystalloid and/or colloid were added for fluid replacement. If cardioplegia was required, the usual crystalloid formula containing 20 mEq/L of potassium was administered. Just prior to termination of bypass, the contents of the dialysis circuit were emptied into the perfusion circuit to be returned to the patient.

[a]Travenol Laboratories, Deerfield, IL 60015

Results

All eight patients were successfully weaned from cardiopulmonary bypass and taken to the Intensive Care Unit. Four of the patients required no post-operative dialysis. The remaining four patients did not require dialysis for at least 48 hours after surgery. Only the patient on chronic dialysis pre-operatively was discharged on a dialysis program. There were three hospital deaths in this series of patients. One patient died of a lethal cardiac arrhythmia, one died of sepsis, and one expired due to a cerebral infarction (Table 2).

Table 3 depicts the pre-operative and post-operative BUN and creatinine levels. There was a mean drop of 68.4% in BUN and a mean decrease of 85.9% in Creatinine levels in the immediate post-operative period. With the exception of the chronic renal patient and two of the patients who expired, the BUN and Creatinine levels continued to decrease. While on bypass, the bicarbonate and potassium levels required careful monitoring. The acetate bath of the dialysis machine appeared to cause metabolic acidosis. This was corrected by the addition of sodium bicarbonate. When a bicarbonate bath was utilized, there was no evidence of metabolic acidosis. In most cases, it was also necessary to add potassium to maintain normal serum levels.

Discussion

Hemodialysis can be accomplished easily and efficiently during cardiopulmonary bypass. This

TABLE 2

Post-operative Data

PATIENT	DIALYSIS REQUIRED	OUTCOME
1.	Yes - beginning 3rd post-op day X 2	Discharged
2.	No	Discharged
3.	Yes - beginning 2nd post-op day X 14	Died
4.	Yes - beginning 2nd post-op day X 11	Died
5.	No	Discharged
6.	No	Discharged
7.	Yes - beginning 3rd post-op day X 10	Discharged
8.	No	Died

TABLE 3

PATIENT	PRE-OP BUN	POST-OP BUN	PRE-OP CREAT.	POST-OP CREAT.	DISCHARGE BUN	DISCHARGE CREAT.
1.	122	82	6.6	5.7	72	2.1
2.	52	28	3.1	3.1	24	1.7
3.	69	65	3.0	4.0	63	4.3 (Expired)
4.	42	35	4.1	3.5	78	6.1 (Expired)
5.	68	44	4.7	3.4	24	0.9
6.	52	34	3.4	2.8	43	2.5
7.	75	47	6.3	4.0	52	7.4 (Chronic)
8.	90	55	2.9	2.8	51	1.5 (Expired)

offers an ideal alternative for dialyzing a hemodynamically unstable patient. However, there are certain parameters which must be carefully monitored.

The acid-base balance is one such area. If an acetate bath is utilized, metabolic derangements may be observed. During a routine dialysis, the patient is dialyzed for a longer period of time and usually at lower blood flow rates. In this situation, the patient is able to metabolize the acetate and acidosis is not usually a problem.[8] The anesthetized patient on cardiopulmonary bypass, in a hypothermic state, is not in a normal metabolic state. This factor, in addition to the shorter dialysis time at higher blood flow rates, could account for the acidosis observed. This acidosis was easily corrected with sodium bicarbonate. When the bicarbonate bath was employed, metabolic acidosis did not occur. The bicarbonate bath is not widely used due to its very short shelf life.[8]

In our experience, hypokalemia was observed pre-bypass to some degree in 75% of our cases. This was corrected by the addition of potassium chloride to the dialysate. The 4.0 - 4.5 mEq/L dialysis bath prevented hyperkalemia successfully. The dialysis unit was employed to hemoconcentrate the patient's blood volume, although the system utilized was not capable of rapid removal of large quantities of volume. If the perfusion circuit was in danger of overflowing, a cell saver was used to rapidly remove and hemoconcentrate the volume. Patients in renal failure usually have increased blood volumes, due to the fact that they are unable to eliminate fluid[10] This can be a problem for the perfusionist. The dialysis machine in conjunction with a cell saver or hemoconcentrator can be utilized to eliminate the excess volume. However, if a cell saver is used extensively, precautions should be taken to replace the lost clotting factors and plasma proteins. Patients in renal failure exhibit anemia and are generally thrombocytopenic[1,10] The hematocrit and platelet count should be monitored, and blood and platelets administered when necessary. Post-operative bleeding can be a problem in these patients.

By maintaining good communication between the perfusionist and dialysis nurse, this procedure can be performed easily and efficiently. Communication is imperative to ensure that both systems are working well together. Thus, the patient receives the dialysis he requires, but does not have his hemodynamic state jeopardized. Because he is on bypass, he is protected from some of the adverse reactions to hemodialysis, such as hypotension and cardiac arrhythmias.[1]

Conclusion

It has been our experience that concurrent dialysis during cardiopulmonary bypass is beneficial. Although the mortality rate of this group was high, we felt the morbidity and possibly mortality rate would have been higher if these patients had not had dialysis during cardiopulmonary bypass. All of these patients were extremely ill when they came to surgery. The fact that we were able to eliminate an additional insult to their already compromised status suggests that this method is advantageous.

References

1. Connors, J.P.: Cardiopulmonary Bypass in Chronic Renal Disease, *Pathophysiology and Techniques of Cardiopulmonary Bypass, Vol. I* Utley, J.R. (Ed.) Baltimore: Williams & Wilkins, 1982, pp. 55-63.
2. Crawford, F.A., Selby, J.H., Bowee, J.D. and Lehan, P.H.: Coronary Revascularization in Patients Maintained on Chronic Hemodialysis. *Circ.* 56(4):684-687, 1977.
3. Kirby, D., Applegate, B., Gabrhel, W., Prewitt, K., Sabbagh, A.H.: Renal Dialysis During Coronary Artery Revascularization: A Case Study *J.E.C.T.* 14(5): 424-427, 1982.
4. Lansing, A.M., Leb, D.E., Berman, L.B.: Cardiovascular Surgery in End Stage Renal Failure. *JAMA* 204(8):134-138, 1968.
5. Seigel, M.S., Norfleet, E.A., Gitelman, H.J.: Coronary Artery Bypass Surgery in a Patient Receiving Hemodialysis: *Arch. Intern. Med.* 137:83-84, 1977.
6. Soffer, O., MacDonell, R.C., Finlayson, D.C., Difulco, T.J., Bradley, J.K., Jones, E.L., Clements, S.D., Rigatti, R., and Clark, E.C.: Intraoperative Hemodialysis during Cardiopulmonary Bypass in Chronic Renal Failure. *J. Thorac. Cardiovasc. Surg.* 77(5):789-791, 1979.
7. Utley, J.R.: Renal Effects of Cardiopulmonary Bypass. *Pathophysiology and Techniques of Cardiopulmonary Bypass, Volume I.* Utley, J.R. (Ed.) Baltimore: Williams and Wilkins, 1982, pg. 40-54.
8. Vreman, H.J., Assomull, V.M., Kaiser, B.A., Blaschke, T.F., and Weiner, M.W.: Acetate Metabolism and Acid Base Homeostasis During Hemodialysis: Influence of Dialyzer Efficiency and Rate of Acetate Metabolism. *Kidney Int.* 18(10):S-62-74, 1980.
9. Wilcox, B.R., Asaph, J.W., and Brown, D.R.: Aortic Valve Replacement in the Anephric Patient. *Ann. Thorac. Surg.* 20(3):282-288, 1975.
10. Guyton, A.C.: *Textbook of Medical Physiology*. Philadelphia: W.B. Saunders Co., 1971, pg. 445-453.