Technique: Arterioarterial Bypass For Renal Transplant Protection During Abdominal Aortic Aneurysmectomy Using a Centrifugal Pump and Limited Heparinization

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Key words: Arterioarterial bypass, abdominal aortic aneurysm, centrifugal pump, renal transplant, in situ perfusion.

Abstract

Today, renal transplant patients have increasing long-term success rates. Since the arteriosclerotic disease plaguing the renal patient seems to be more intensified after hemodialysis, expectations are that greater numbers of renal transplant patients with aortic disease will be seen.

When clamping of the aorta occurs during aneurysmectomy, perfusion of the transplanted kidney is compromised. A Bio-Medicus a centrifugal pump was utilized in the repair of an abdominal aortic aneurysm to protect the transplanted renal graft. The bypass consisted of cannulated sites of the left axillary artery and the left femoral artery with the centrifugal pump unit interposed. The resulting bypass was considered to be an in situ perfusion of the kidney. A small amount of heparin was given. The transplanted kidney excreted urine the entire procedure; the creatinine levels remained stable, and the patient did well.


Introduction

Complications associated with arteriosclerotic vascular disease occur with a higher than normal frequency in patients with chronic renal failure, especially those undergoing long term dialysis. Despite renal transplantation, previous vascular disease may be progressive and result in later limb- or life-threatening complications. Major arterial reconstructive surgery requiring protection of the kidney in an immuno-suppressed renal transplant patient will become more common with long-term transplantation successes.

Aortic surgery in recipients of renal transplants may require a method of maintaining intraoperative graft perfusion. Several innovative methods of using shunts or dealing with the problem of ischemia of the transplanted kidney have been used.

Some of these measures to protect the transplanted graft have included permanent or temporary axillo-femoral vascular shunts, hypothermic extracorporeal in situ perfusion of the renal graft by way of femoral cannulation, in situ periodic infusions of cold (4°C) saline or Ringer’s solutions, heparin-bonded aortic or aorto-femoral shunts, and double clamping of the aorta (utilizing natural collateral circulation) with or without cold infusions to the transplanted kidney.

Intraoperative and post-operative complications may include ischemia or irreversible damage to the transplant, embolization of aneurysm sac material to the extremeties, and possible damage or infection of the cannulation sites.

The arterioarterial bypass system utilizing the Bio-Medicus centrifugal pump and cannulation of the left axillary artery and the left femoral artery offers an alternative procedure which allows a relatively uncluttered access to the aorta while providing protection to the transplanted kidney.

Aorto-aortic and aorta-femoral bypasses with the centrifugal pump have been utilized in repairs of the thoracic aorta. Not only is the after-load reduced, but the pump provides perfusion to the spinal cord, viscera, and extremeties. Therefore, the problems of hypoxia, hypotension, and vascular pooling are decreased. Flows in the range of 1-4 liters a minute and activated clotting times (ACT) in the range of 150-200 seconds have been used yielding good success.

The centrifugal properties of the pump make air embolization difficult, an important feature when a reservoir is not part of the circuit. Low density micro-air bubbles will remain in the center of the vortex created and should not be propelled into the outflow line. The pump is somewhat inflow-responsive and outflow resistance dependent. Forward flow of blood decreases or stops if high pressures develop in the outflow line.

Case Report

The patient was a 65-year old white female who presented with an abdominal aneurysm (AAA) which had been detected by a routine periodic ultrasound. She had undergone a cadaveric renal transplant (CRT) in the left pelvis 5 years prior to this admission after 44 years of end-stage renal disease thought to be secondary to a congenital problem. Continuous ambulatory peritoneal dialysis (CAPD) followed by hemodialysis via a left forearm arteriovenous fistula (AVF) had been attempted for three years prior to the transplant. She had demonstrated hypertension...
for the past 25 years as well as congestive heart disease prior to the CRT. She also had undergone right carotid endarterctomy for transient ischemic attack three years prior to this admission. The AAA (3 cm in diameter) had been detected 18 months prior to admission; by admission, it had grown to 6 cm in length x 4.7 cm x 4.7 cm in diameter. It was decided to proceed with aneurysmectomy because of risk of rupture. A renal flow scan showed good renal flow and function of the renal graft.

On physical exam, there was a palpable abdominal mass with peripheral pulses full and regular. She appeared to have no signs of rejection or infection. Systemic hypertension was under control; episodes of gastritis were treated with antacids.

Her blood pressure as 160/40 mm Hg; her weight was 61 kg and her height was 5 feet, 1 inch. An ECG demonstrated severe left ventricular hypertrophy with a MUGA showing an ejection fraction of 81% and left ventricular hypertrophy. Since the renal transplant was functioning well, the patient herself requested that special measures be taken to protect the kidney.

The patient was brought to the operating room and placed in the supine position. A midline incision from the xiphoid to the pubis was made. The peritoneum was entered. There was a large, saccular aneurysm of the infrarenal aorta extending from the infrarenal bifurcation right up to the level of the left renal vein. The neck of the aneurysm was secured, and then the left and right common iliacs were isolated. Blood was drawn to pre-clot a bifurcated 16 cm x 8 cm x 40 cm woven Velour graft.

As per protocol, she was given 20 mg Lasix and 25 Gm of Mannitol 15 minutes before anticipated aortic clamping. She was also maintained on a Dopamine infusion of 2 mcg/Kg/min. of body weight. The patient was heparinized with 5000 units of beef lung heparin. Usual heparinization is 100 units-150 units per kilogram of body weight. A #12 French chest tube was placed in the left axillary artery and a #16 French chest tube was placed in the left femoral artery.

The perfusion system consisted of a pre-primed (approximately 700 ml of beef lung heparin in 300 ml plasmalyte pH 7.4 [b] Bio-head BP-80 [a] and a flow probe. At each of the inflow and outflow of the pump there was a five feet length of 3/8" I.D. Tygon [c] tubing. This particular system has been used extensively in the liver transplant program at this health center. The inflow of the pump was connected to the axillary cannula, and the outflow was connected to the femoral artery cannula with appropriate size connectors.

The aorta was cross-clamped and the bypass was started. Initially the flow was 600 ml/minute but rose gradually to 1 L/minute. Close visual inspection of the axillary cannula as well as grasping the inflow line to the pump (to detect any "chattering" which might represent negative pull on the axillary vessel) aided in determining pump flow.

Normal blood flow to both natural kidneys is approximately 21% of the cardiac output but may range from 12-30% of the cardiac output. Average flow to both kidneys in a 70 Kg man probably is about 1200 ml/min although the flow may not be evenly distributed. In an abdominal aortic aneurysmectomy with in situ renal perfusion utilizing a pump-oxygenator, it was found that urine production did not start until the flow surpassed 670 ml/min; the eventual flow was 850 ml/min. Good urine production ensued.

According to Dr. Robert Gordon (Associate Professor of Surgery at University of Pittsburgh Health Center), transplant surgeon and surgeon of this procedure, the optimal and maximum flow to a transplanted kidney is not known. Flows in the range of 500 ml-1500 ml/min. are probably acceptable.

Indeed, the entire flow of 1 liter did not go to the kidney but also some to the pelvis by way of a branch of the internal iliac artery. A flow of 500 ml/min in a partially heparinized bypass system may be too low to prevent stasis and deposition of elements in the system. (This bypass system was inspected post-bypass with no observation of deposition anywhere in the system.)

The aneurysm was opened and the lumbar and middle sacral vessels were oversewn. There was considerable atherosclerosis right down to the bifurcation. It had been decided to do bi-iliac grafts; both common iliacs were transected and grafted. The left leg was revascularized first after 58 minutes clamp time, and the bypass was terminated. The right limb was subsequently revascularized. The patient had excellent perfusion in the iliac arteries with full pulses prior to closure. Her AVF continued to have good flow (via Doppler monitoring) by way of collaterals even though the cannulated axillary artery was clamped during bypass.

The transplanted kidney excreted urine during the entire procedure. The total urinary output was 2071 ml of which 370 ml was excreted during the bypass of 75 minutes duration. She also had a blood loss of 2000 ml for which she received five units of packed red cells.

As stated, the flows on bypass ranged from 600 ml/min to 1 L/min Cardiac outputs ranged from 5.0 L/min prebypass to an average of 4.5 L/min. on bypass and after. Upper body pressures ranged from 110/70-140/70 mm Hg pre-bypass to 110-120/50 mm Hg on bypass. Pulmonary artery pressures were 26/15-40/26 mm Hg pre-bypass to 23/14-25/13 mm. Hg. on bypass. Central venous pressures were 4-7 mm. Hg. pre-bypass to 7-9 mm Hg on bypass. The activated clotting times were 130 seconds at control to 180, 210, 190, 170, and 160 seconds on bypass. No protamine was administered.

The surgery lasted approximately four hours; the patient did well post-operatively. Creatinine levels never rose above 1.4 mg/dL and the BUN ranged from 24 mg/dL on the day of surgery to 27 mg/dL peak to 20 mg/dL on the day of discharge. According to her physician, urine output remained "excellent" and pulses were good. She was maintained on her antihypertensive, anti-rejection medications and was discharged seven days post-op with clean wounds and feeling well.

a. Bio-Medicus, Minneapolis, MN 55334
b. Travenol Labs, Deerfield, IL 60015
c. Norton Industrial Plastics, Akron, OH 44309
At follow-up, the patient was doing well with no negative sequelae. An abdominal ultrasound three weeks post-operatively revealed the transplanted renal artery to be normal.

**Summary**

The use of the arterioarterial bypass system for preservation of a transplanted kidney during aortic aneurysmectomy yielded excellent results and would be used by this group of surgeons again for abdominal (i.e., transplanted or pelvic) kidneys involved with aortic surgery.

**References**


