Symposium

Answers to earlier SYMPOSIUM questions are trickling in and will be printed as they arrive. In order to give everyone a chance to respond, we are repeating all of these questions this issue with the assurance that any contributions in answer to early questions will be utilized.

The following are a new set of problems to replace the old.

1. *Given: A infant requires intra-cardiac surgery.*
   Question: Describe in detail the rationale and pump oxygenator circuitry your team prefers during such cases. How does this vary with each type of defect?
2. *Given: Concern for the mental outlook of the chronic dialysis patient.*
   Question: Explain the outlook your team wishes to develop in the patient, how this is accomplished by the medical personnel, and the effect upon the patients.
3. *Given: Patients are to be trained to accomplish dialysis at home.*
   Question: Summarize your training program emphasizing what you feel are its strongest points.
4. *Given: The aortocoronary bypass graft has probably become the most frequent cardiac procedure of late.*
   Question: Describe the rationale, technique and pump-oxygenator circuitry your team favors for this procedure. A discussion of results may also be included, if you like.
5. *Given: Organ preservation systems are many and diverse.*
   Question: Describe the preservation system you use and why this particular technique was chosen.
6. *Given: The increasing amount of interest shown in the impedance plethysmograph (sometimes called the impedance cardiograph).*
   Question: Outline the concepts upon which it operates and its potential value to the study of hemodynamics, or a summary of your experience with this unit, if you prefer.

Please reply by letter, include any illustrations you might desire, and send your reply to:

Journal of Extra-Corporeal Technology

287 East Sixth Street

Saint Paul, Minnesota 55101

Ready repeated access to the circulation of a patient in renal failure is the sine qua non of successful therapy with the artificial kidney. Chronic hemodialysis became feasible only when Quinton et al developed the external prosthetic arteriovenous shunt (1). By virtue of this achievement, patients with chronic renal disease could be intermittently dialyzed as the primary modality of therapy or as a temporary measure before and after renal transplantation.

The crucial position of blood vessel accessibility has been appreciated by those maintaining a chronic dialysis center and it is generally agreed that the arteriovenous shunt is the "weakest part of the treatment system." (2).

It is hoped that the following review of the techniques we have employed in establishing this vital link between the uremic patient and artificial kidney will be of help to those who are involved in the care of patients on chronic hemodialysis.

Methods of Gaining Access to Blood Vessels

Access to blood vessels may be required for either a single dialysis or for repeated dialyses (Table I). These two approaches cannot be equated with acute (reversible) or chronic (irreversible) renal failure respectively. We have encountered an increasing number of patients with hypercatabolic renal failure who require daily dialysis or repeated dialyses over a period of weeks. On the other hand, patients who are candidates for chronic hemodialysis are often seen with severe uremia and urgently require hemodialysis when they are in less than ideal condition for an operative procedure, however minor.

A simple method of gaining access to the circulation for a brief period of time is of value for these patients as well as those with acute renal shutdown. Other patients on a chronic dialysis program may require a dialysis while an infected or thrombosed shunt renders this device unsatisfactory for use. Although we have had to utilize an external shunt or an arteriovenous fistula immediately after its insertion or construction, we are loath to do so and prefer, instead, to use one of the techniques of blood vessel access for a single dialysis.

A. Single Dialysis

1. *Direct Cannulation of Artery and Vein:* This procedure is simply a cut-down on the vessels to be used. The radial artery at the wrist and an adjacent vein are usually employed. It has the great disadvantage of destroying these vessels for any further use. We employ this technique rarely because of the aforementioned reason. A situation in which it is indicated is in the dialysis of infants. A three-year-old child was successfully dialyzed by direct cannulation of the vessels in the groin with polyethylene tubing.

TABLE 1

Methods of Gaining Access to Blood Vessels for Hemodialysis

A. Single Dialysis
   1. Direct cannulation of artery and vein
   2. Venipuncture
   3. Insertion of double lumen catheter (McIntosh tube) into inferior vena cava via saphenous vein
   4. Percutaneous catheterization of aorta and/or inferior vena cava by two separate catheters using Seldinger technique (Shaldon catheters)

B. Repeated Dialysis
   1. External arteriovenous prosthetic shunt (silastic-teflon shunt)
      a. Upper extremity
      b. Lower extremity
   2. Creation of arterio-venous fistula
      a. Venipuncture
      b. Veno-venous shunt.

Gaining Access to Vessels for Hemodialysis

S. AMJAD HUSSAIN
M.B., B.S.

and

J. C. ROSENBERG
M.D., Ph.D., F.A.C.S.

Associate Professor of Surgery
Department of Surgery
Wayne State University
School of Medicine

2. *Venipuncture:* In 1962 Cimino and Brescia described their experiences with simple venipuncture for hemodialysis (4). They obtained adequate flow rates with this technique. Stein has recently added his endorsement of this approach (5). We have employed simple venipuncture as a conduit for returning blood to the patient from the dialysis coil.

Occasionally we have encountered venospasm manifest as increasing resistance to flow and no obstruction is encountered on irrigating the needle. Therefore, we do not prefer simple venipuncture as the source of blood flow to the dialysis unit. When this technique is used, we employ a 15-gauge needle which consists of polyethylene tubing and a pointed stainless steel obturator which is removed when the vein is entered.

We have found it useful to infiltrate 1% xylocaine around the vein when it is being used as a site for hemodialysis via a venipuncture.

3. *McIntosh Tube:* In 1959, McIntosh, Berry, Thompson and Peschel described a double lumen catheter which could be positioned in the inferior vena cava through the saphenous vein to function as the inflow and outflow lines of the dialysis unit (6). We have always found this tube simple to insert and effective.

Occasionally, we have had poor flow rate from the "arterial" or proximal component of the catheter. Repositioning the McIntosh tube often corrects this. We have also found it possible to reverse the positions of the tube and obtain effective dialysance, i. e., the proximal catheter (which should be connected to the kidney as the arterial line) is used as the return line from the kidney.

In order to avoid hemorrhage from the saphenous vein, a suture is inserted around the vein and brought through the skin. The suture is tied after removing the catheter. This suture can be removed after 4 to 5 days.

In two patients, we removed the McIntosh tube and sutured the vein with the hope of keeping it patent and then re-using the vein. Although we succeeded in doing this, we do not recommend it. The saphenous vein had thrombosed and required a thromboectomy before the tube could be reinserted.

McIntosh tube insertions are preferably done in the operating room with local anesthesia. However, the procedure can also be done on the ward. One patient had sufficient bleeding to merit return to the operating room for ligation of the saphenous vein. None of the wounds became infected. We attribute this to the fact that we perform this procedure in the operating room and consider it a major procedure.

All patients were dialyzed with whole-body heparinization and the tube was removed as soon as the dialysis was completed. We hesitate to leave the tube in the inferior vena

TABLE 2

Complications of the Silastic-Teflon Arteriovenous Shunt (Scribner-Quinton)

1. Thrombosis
2. Infection
3. Hemorrhage
4. Aneurysm formation
5. Erosion

cava for any prolonged period of time because of its large size and the danger of thrombosis and pulmonary embolism.

4. *Percutaneous Catheterization of Aorta and Inferior Vena Cava:* Seldinger's technique of inserting catheters into the major vessels using a needle puncture and a guide wire has found application to patients with renal failure (7). Shaldon was the first to utilize this principle in 1961 (8). In addition, we have employed 8-French disposable dacron catheters. The catheter is easily inserted into the aorta and, with a little experience, into the inferior vena cava, through the femoral vessels. With a little skill, 2 catheters can be positioned in the inferior vena cava. The brachial artery may also be used. The catheters designed for arteriography do not function well and are not recommended.

B. Repeated Dialyses

1. *External Arteriovenous Prosthetic Shunt:* The device invented by Scribner and Quinton has undergone some minor changes and other techniques have been proposed as improvements. However, their shunt is the standard against which all other techniques must be measured (11-16). It is the most widely used method of obtaining access to blood vessels for hemodialysis.

Elderly patients with arteriosclerosis are not candidates for this procedure. Their non-resilient vessels preclude introduction of a large catheter over a guide wire.

Since heparinization is required during hemodialysis, a 15-minute period of compression is mandatory when the catheter is removed. Hematoma formation is the only complication we have encountered with the use of this technique. On one occasion it was of major consequence.

Shaldon's method of gaining access to the circulation is gradually replacing the McIntosh tube in our practice. The latter remains valuable for the elderly or as an alternative to the percutaneous catherization when technical problems limit the use of the latter.

Most often we have combined the Shaldon catheter in the femoral artery for the arterial line and simple venipuncture for the venous return.

Complications of the Silastic-Teflon Shunt

All of the reported complications of this operation are shown in Table II.

Thrombosis is the most common problem. The thrombus appears to begin inside the blood vessels (usually the vein) and can be related to hypotension with poor blood flow and/or damage of the intima secondary to trauma. Declotting is often effective.

Several of our patients have been anticoagulated but in none were we impressed with the existence of a hypercoaguable state as described by Erickson et al. (17). They found a significant increase in measured clotting factors in the blood of patients who developed recurrent cannula clotting. They reported one patient who had over 100 clotting episodes in 15 months in spite of cannula revisions.

We have not encountered such "clotters" and can attribute most of our problems to faulty technique, improper cannula care, and hypotension. Nonetheless, we have occasionally employed anticoagulants as recommended by Wing et al. (19).

Suspected infections are treated with vancomycin as recommended by Rigg (18).

Hemorrhage can occur when the cannula connection is dislodged. It should be promptly treated by clamping the shunt tubing. We now give all patients with external shunts two small Diffenbach bulldog clamps to clamp the Silastic tubing.

Aneurysm formation and erosion are both treated by removing the prosthetic shunt.

Shunts in the Upper and Lower Extremity

The majority of shunts are inserted into the upper extremity but can be placed in the lower extremity.

The lower extremity has proved to be an excellent site for implantation of shunts; in contrast to the reports of Faris et al. (20). It is the preferred site of insertion in patients requiring dialysis for post-traumatic and postoperative renal failure since these patients are often uncooperative and require intravenous fluids. These factors make it easier to care for the patient when the shunt is located at the ankle. The latter site is also easier to immobilize with a posterior molded splint. There is no rotary motion at the ankle as there is at the wrist; thus allowing for less trauma to the vessels after the shunt is inserted.

We have been able to cannulate a previously ligated radial artery in a retrograde direction and obtain excellent flow rates. The palmer arch, supplied by the ulnar artery, provided sufficient collateral blood flow to produce a palpable pulse in the ligated radial artery. A similar experience has been reported by Ramiriz et al. (16).

Care of the Silastic-Teflon Arteriovenous Shunt

The patient must be involved in the care of the shunt early in its life time. We have provided some of our patients with stethoscopes to check for the bruit and have instructed them in the appearance of a clotted shunt.

The presence of a high-pitched sound superimposed on the bruit of the arteriovenous shunt has often been followed by shunt thrombosis and we vigorously irrigate these shunts with heparinized saline to dislodge the thrombus.

We do not use stabilizers because of the difficulty of attaching them to the skin. Instead, we prefer to stabilize

* Supported by grants from the Detroit Receiving Research Corporation and Michigan Heart Association.

the silastic tubing with paper adhesive tape. All patients are instructed to limit the use of the extremity bearing the external shunt in order to minimize the possibility of trauma.

The skin surrounding the shunt is cleansed daily with alcohol, occasionally with soap. The sites of exit are similarly cleansed with sterile applicators. Peroxide may be used to remove clotted blood. We rarely apply antibiotic ointment since it has resulted in skin reactions.

Arteriovenous Fistula

2. In 1966, Bresica, Cimino et al. improved upon their previously reported simple venipuncture technique by surgically creating an arteriovenous fistula and then inserting needles into the "arterialized" vein in order to obtain sufficient blood flow for the artificial kidney (21). The procedure was enthusiastically received (22, 23). It may prove to be the preferred method of gaining access to the blood vessels in younger people who wish to be more active than an external shunt permits them to be.

A fistula between the cephalic vein and radial artery works well except in patients who had had a shunt in these vessels previously or who have had repeated venipunctures. The cephalic vein is frequently used for intravenous fluid therapy. It can be partially thrombosed and not provide an adequate conduit for the arterial flow. Whenever veins other than the cephalic, viz. deep veins or small superficial vein, are used, the resulting fistula is more likely to be inadequate. Although the fistula may remain patent, as proved by a continuous murmur, arterialization of the superficial veins may not be achieved.

The complications of A-V fistula are now being recognized frequently. The most important complication is enlargement of fistula by stretching and its possible hemodynamic effect on the cardiovascular system. We have seen two patients with hypertension and congestive heart failure. Both were in the pediatric age group who were adversely affected by the A-V communication.

Some of the patients complain about the loud machinery murmur produced by the fistula particularly at night. A firm dressing may obviate this problem.

Summary

Our experience with problems of gaining access to blood vessels for hemodialysis is reviewed. The complications encountered are detailed and recommendations made for their prophylaxis and management.

One of the chief problems in maintaining the life of a patient with chronic renal disease by repeated hemodialysis is the vascular connection between the patient and the artificial kidney. It is our feeling that the duration of a "trouble-free" shunt is a direct function of the time and effort expended in keeping this device "trouble-free."

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