New Technique for Creating Buried Arterio-venous Fistulæ

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The life expectancy of external shunts (Quinton et al., 1960) averages somewhat less than six months for either arterial or venous sites, therefore, a patient with a life expectancy on maintenance dialysis of five years would require a minimum of ten different arterial and venous access sites. In addition to the inconvenience of an extracorporeal device, the problem of repeated clotting of arterial and venous limbs of the shunt becomes a major factor. The threat of accidental dislodgement of the extracorporeal device is always present. Some elaborate declotting techniques have been developed, using balloon-tipped catheters, systemic anti-coagulants, fibrinolysin, etc. The presence of cutaneous ostia necessitated by the placement of an internal-external shunt creates a possible source of infection. It is desirable in the prospective recipient for renal transplantation to have as few possible loci for infection and elimination of the cutaneous ostium diminishes the possibilities.

Further developments in the art of vascular access brought into being the buried subcutaneous arterio-venous fistula (Cimino). This shunt, as initially described (Brescia et al., 1966) was constructed free-hand, was a side to side connection, and permitted adequate arterIALIZATION of the cutaneous venous system in the forearm. There was a tendency over a period of time for the side to side orifice to enlarge and permit ever increasing shunting of blood into the venous system. Uncontrolled shunting may lead to cardio-dynamic alteration.

An arterio-venous fistula is defined as a communication between an artery and vein and implies all gradations of 'orificial' size. A 'pin-point' communication allows a very small admixture of arterial and venous blood, and the local and systemic haemodynamics are not altered. With increasing size of A-V communication, changes take place in the local pressure relationships and ultimately in direction of flow around the fistula. The fistula is said to be 'significant' when the A-V communication approaches the size
of the 'parent' artery. The flow pattern around a significant fistula (side to side) is as follows: the blood flow is reversed in the artery distal to the fistula, and there is a retrograde flow of arterial blood into the distal vein. An orthograde flow is maintained in the vein proximal to the fistula, but it carries predominately arterialized blood. To effectively arterialize veins proximal and distal to an arterio-venous fistula, a significant fistula must be designed. When veins are arterialized with a direct end to end communication, the full thrust of the arterial flow is transmitted into the venous system and not dispersed distally. When the communication is made at the wrist, the venous circulation distal to the fistula is seldom of use. Therefore, a direct end to end anastomosis may be of greater utility. There is usually more resistance in the venous circuit of an end to end arrangement because the main arterial flow has to be accommodated by the proximal circuit.

An end to end communication may be constructed free-hand or by use of a vascular 'stapling' instrument. We have had experience with more than 20 patients in whom an end to end anastomosis was made with the vascular stapler (Nakayama). A singular advantage of this technique is the insertion of a metallic ring which maintains a communication between artery and vein at a constant size. The staple-rings come in three sizes: 2, 3 or 4 mm in

Figure 1. Vascular stapling device armed with rings, prepared for approximation and anastomosis.
Figure 2. End to end anastomosis at the wrist, showing vessels impaled on spikes

diameter. A transverse incision is made 1 cm proximal to the proximal flexion crease of the wrist, and the radial artery and the cephalic vein identified. These vessels must be dissected proximally and distally for a distance of approximately 2 cm, and after the adventitial tissues have been removed, both vessels are ligated as far distally as the dissection is carried. Proximal atraumatic occluding clamps are applied, and the vessel sectioned near the distal occluding ligature. The stapling clamps are armed with the circular staples and are now ready for use (Figure 1). One of the vessels is pulled through the circular ring, everted, and impaled on the spikes protruding from the ring. The other vascular end is treated in a like fashion, and the ring holders are approximated in proper position as assured by 'keys' in the instrument. The projecting spikes are then crimped over anvils which are built into the ring holders, using a compression instrument. Anastomosis is now complete and intima-to-intima approximation accomplished. The occluding clamp is removed from the vein, followed by arterial declamping. Flow through the anastomosis should be prompt and arterialized blood visualized on the venous side (Figure 2). The completed anastomosis is allowed to fall back into the deep tissues. The location of the ring should be noted, and any tissues which impinge on it, tending to angulate, should be removed or severed. This may necessitate creating a small defect in the subcutaneous tissues. The subcutaneous tissues are then closed in
layers using 4-0 chromic catgut for the deep tissues and 4-0 silk in the skin. If some angulation has occurred at the anastomosis site due to tissue distortion, it is advisable to place the wrist in mild palmar flexion for several days.

When the arterial and venous structures are inadequate in the distal forearm, we have placed buried fistulae in the ante-cubital fossa, between radial or ulnar arteries and adjacent veins. In this location it is desirable to create a side to side shunt (Figure 3).

It is usually desirable to allow the fistula to 'mature' for several days before use; however, it has been used on the same day it was designed. In time, the arterialization of the veins makes venepuncture a fairly easy accomplishment.

Some of the fistulae have failed, but usually adequate cause can be found, e.g. fracture with casting, direct trauma, etc. Spontaneous closure has been rare except in the post-transplanted fistula-bearing patient.

The detailed technique for gaining access to these arterialized veins will not be discussed; however, in our unit, the nursing staff has been trained in its use. We advise that the needles be inserted at some distance from the venepuncture to minimize bleeding from around the needle tract (Figure 4). The use of a blood pump is almost routine when using the buried
fistula system. The venous effluent from the dialyzer flows into a blood vessel with greater pressure than encountered in the inflow side of an external shunt. A caution should be given regarding placing needle tips too close to the arterio-venous communication, and also on repeated needle punctures in one small area of skin, which may lead to infection or necrosis and subsequent thrombosis of the arterialized vein. The systemic effect of the end to end arterio-venous communication is being studied by testing the cardiac output. It is generally increased in this group of patients, but decreases only slightly when shunts are closed. About one-half of the patients have a buried shunt in both upper extremities, which can be used alternately. A simple calculation, using Poiseuille's equation, will verify that blood flow through one 6 mm shunt is greater by a factor of 8* than the flow through two 3 mm openings. We have not been able to implicate the presence of buried shunts in the genesis of cardiac failure.

This is one additional means of gaining access to the vascular system to ensure a continued man-machine interaction in this most salutary of bio-engineering organ-support systems.

*Poiseuille's equation applies to Newtonian fluids in a tube and can only be used as a rough approximation here. Ed.
REFERENCES