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Aorto-Iliac Arterial Substitution Utilizing Subcutaneous Grafts

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SINCE Freeman's [9] description in 1952 of the use of a superficial femoral artery to carry blood directly from one femoral artery to the other, subcutaneously placed grafts have been utilized to bypass diseased abdominal arteries.

In 1958, McCaughan [18] sutured a Dacron prosthesis to the left external iliac artery, brought it pre-peritoneally across to the right groin, anastomosed it side-to-end to the right profunda femoral artery and end-to-side to the popliteal artery, bypassing occlusions of the right iliac, common and superficial femoral arteries.

In 1959, Lewis [13] resected an abdominal aortic aneurysm but was unable to anastomose the proximal end of a homograft replacement to the thoracic or abdominal aorta because these segments were the site of a dissecting aneurysm. He resected the middle third of the clavicle, sutured a Nylon graft end-to-end to the proximal subclavian artery, brought the graft down the chest wall and into the abdomen at the level of the xiphoid process for anastomosis to the homograft. This operation demonstrated that arteries in the upper extremity could be used to supply the lower half of the body.

We were confronted with the problem of a patient who had repeated ruptures of the proximal anastomosis of an infected abdominal aortic Dacron prosthesis used as an aortic replacement following resection of an aortic aneurysm. Ultimately, it was necessary to remove the graft. To remedy the circulatory deficit, a Dacron graft was sutured to the descending aorta brought out of the chest below the twelfth rib, down the lateral abdominal wall and sutured end-to-side to the left common femoral artery. A side-arm was anastomosed to this graft in the left groin and brought suprapubicly across to the right groin and anastomosed end-to-side to the right common femoral artery. This abdominal aortic

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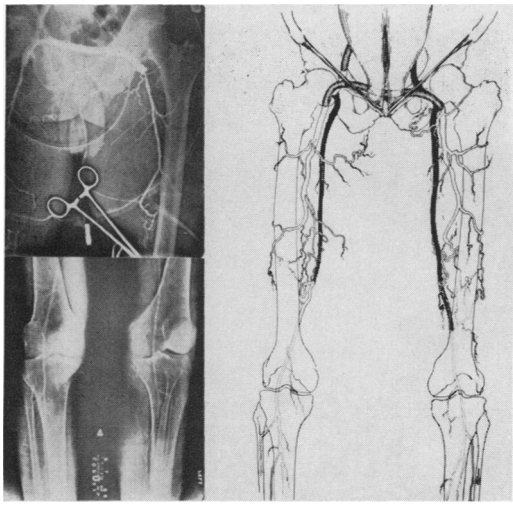

FIG. 1. Femorofemoral bypass graft for ischemia of left leg from left iliac occlusion. An aorto-right-iliac bypass had been performed several years previously.

substitute functioned until the patient's death from intra-abdominal sepsis one month later.[1]

In 1962, Vetto[23] reported ten transabdominal subcutaneous femorofemoral graft operations to bypass unilateral iliac occlusive disease in poor-risk patients. Nine of the procedures were effective. Circulation in the good leg was not compromised in any instance, although in one patient a simultaneously placed femoropopliteal bypass occluded in the immediate postoperative period.

In 1962, almost simultaneously our group[2] and Louw[14, 15] performed bypass procedures for aorto-iliac occlusions by Dacron graft carried from the axillary artery to the femoral artery. Our first patient was to have aortic-iliac thrombectomy for ischemia of the right leg on March 25, 1962, but cardiac arrest occurred during induction of anesthesia. Acute myocardial ischemia was indicated by the electrocardiogram. The leg was non-viable from the thigh down. Axillofemoral bypass was carried out under local anesthesia.[2] The operation salvaged the leg and the graft remained patent until the patient's death 2½ years later from myocardial infarction. A second axillofemoral bypass was performed on another patient to bypass intraperitoneal infection of a Dacron graft and permitted removal of the graft.[2]

Axillofemoral bypass was combined with femorofemoral bypass and simple ligation of a rupturing abdominal aneurysm in a poor-risk patient in 1964. In another patient, the graft functioned spontaneous thrombosis of the aortic aneurysm resulted. These procedures demonstrated that the axillary artery was adequate to supply the arm and both legs as in no instance was circulation to the arm compromised.[3]

Since that time numerous publications report utilization of subcutaneously placed bypass grafts for aorto-iliac arterial disease.[4, 6-8, 10-12, 16, 17, 19-21, 24-26] Our report reviews experience with 60 subcutaneous arterial bypass procedures.

Operative Technic

The ascending and descending thoracic aorta can be used as the proximal source for subcutaneous bypass[1] but we prefer to avoid thoracotomy and to utilize a suitable superficial artery.

Subcutaneous bypass operations have been used for femorofemoral and axillofemoral bypass. Knitted Dacron tubes 10 mm. in diameter are considered optimal although 8 mm. Dacron grafts have also been used. Local or light general anesthesia may be used. If there are two operating teams bypass procedures can be performed in less than one hour.

Femorofemoral bypass is the procedure of choice when occlusion is limited to one iliac system (Fig. 1). The common femoral artery is the most accessible donor vessel, but the external iliac or deep femoral can be used. The Dacron tube can be carried preperitoneally or subcutaneously across the pubis, to an opposite vessel. The anastomoses are made with an obliquely cut end of the Dacron graft to avoid narrowing. Orientation of the grafts in a transverse direction or reverse oblique angle from the femoral artery has not limited flow. Since

reconstructions parallel flexion creases, the graft rarely kinks or obstructs.[4, 23, 24]

Axillofemoral bypass has been used as an alternative to femorofemoral when there is aortic disease or involvement of both iliac systems. The axillary artery is a satisfactory inflow vessel if there is no proximal occlusive disease of the subclavian artery. Decreased blood pressure or diminished pulses in the arm, bruits or thrills over the subclavian artery contraindicate use of the axillary artery unless it is patent by angiography. The axillary artery is rarely diseased and the proximal one third (between the clavicle and the pectoralis minor muscle) is the segment of choice for anastomosis. The first portion of the artery is fixed to the chest wall so that the graft does not flex with motion of the arm and there is only one small collateral branch (the highest thoracic). The tunnel for the graft is developed behind the subclavian vein deep to the pectoral musculature and downward and laterally to the midaxillary line where a small counter-incision facilitates further development of the tunnel to the groin. This portion of the tunnel can be carried subcutaneously or deep to the external oblique fascia. The tunnel is best carried posterior to the anterior axillary line at the waist so that angulation or kinking is less likely to occur when the patient sits or bends. End-to-side anastomosis with the common femoral, or profunda femoral is carried out in conventional fashion (Fig. 2). If the ipsilateral axillary artery is diseased, the contralateral artery can be used. The graft is then brought down to the level of the ipsilateral anterior iliac spine and curved transversely across the lower abdomen to the opposite femoral artery.[12]

The final procedure used frequently is a combination of axillofemoral and femorofemoral bypass (Fig. 3). In this, a graft is carried from one axillary artery to the corresponding femoral artery. A second graft is anastomosed to the first in the lower abdomen or groin, and carried to the opposite femoral vessel. This reconstruction provides

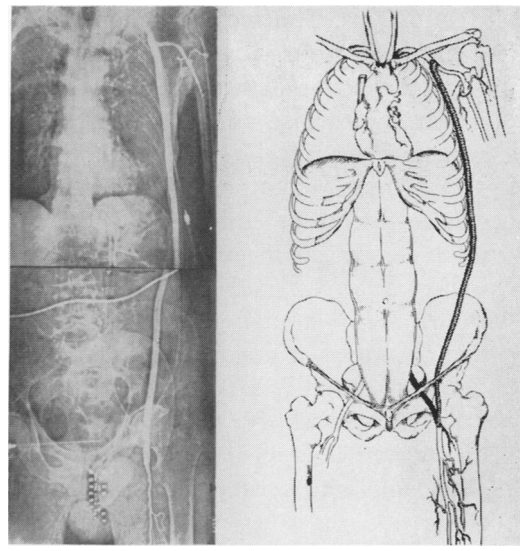

FIG. 2. Left axillofemoral bypass has been performed for bilateral iliac occlusion. There is an associated left superficial femoral occlusion. The patient complained of rest pain in the left leg.

total substitution for the infrerenal abdominal aorta and permits retrograde perfusion of the hypogastric arteries if one or both external iliac arteries are patent.

Indications for Operation

Subcutaneous arterial bypass is used when the risk of operation is high because of associated disease or anticipated tech-

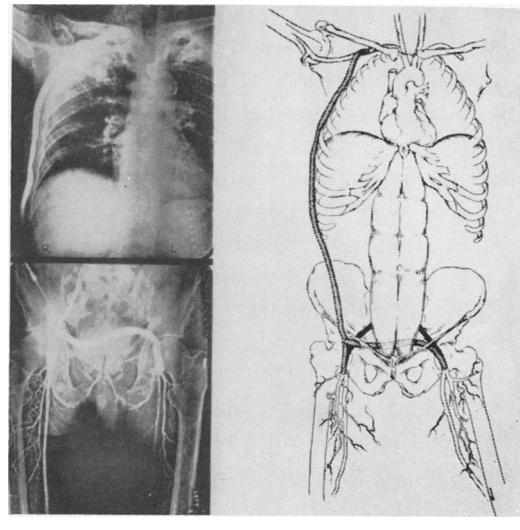

FIG. 3. Right axillofemoral bypass and simultaneous femorofemoral bypass (combined graft) has been performed in this patient with bilateral iliac artery occlusions.

nical problems. The most common indication has been severe pulmonary or cardiac disease. A patient with myocardial infarction and low cardiac output with hypotension may develop ischemia of the extremities secondary to pre-existing aorto-iliac occlusive disease or embolism. In this circumstance, subcutaneous arterial bypass can be performed under local anesthesia with less risk than amputation.

Specific vascular lesions for which subcutaneous arterial bypass has been of value are aorto-iliac occlusive disease, aneurysms of the aorto-iliac system or infection of the peritoneum, retroperitoneum or inguinal regions.

Aorto-iliac occlusive disease may be bypassed by using as a source of inflow the contralateral femoral artery or the axillary artery, depending upon whether the disease is unilateral or bilateral. The contralateral axillary artery can be utilized if there is disease in the ipsilateral subclavian artery. In poor risks, subcutaneous bypass avoids systemic morbidity, as the procedures can be carried out on the surface of the body.

Subcutaneous arterial bypass may occasionally be of value in abdominal aortic aneurysms. Six aortic substitution operations consisting of axillofemoral bypass in combination with femorofemoral bypass for aneurysmal disease have been performed. Simultaneous proximal aortic ligation was carried out in two,[3] distal ligation in two, and no ligation but with the graft in conjunction with the normal aorta in two.

The final indication for subcutaneous arterial graft is infection in a previously placed aorto-iliac graft. In this instance, the treatment is total removal of the infected graft with ligation of the infrarenal abdominal aorta and iliac arteries and bypass of the abdominal vessels, using axillofemoral, femorofemoral grafts, or a combination of both.

Contraindications and Complications

The few contraindications to subcutaneous arterial grafting are essentially those for any bypass procedure, such as inadequate inflow or outflow vessels or infection along the route of the graft.

No serious complications followed use of subcutaneous arterial bypass. Although an arm vessel, such as the axillary artery might seem to be incapable of supplying blood to the lower extremities, this has not been the case. All operations restored circulation comparable to that following conventional procedures. No difficulties could be related to "steal" of blood from the good arm or leg with either axillofemoral or femorofemoral procedures. Measurement of free flow from the graft after axillary artery anastomosis has shown that the capacity for inflow of normal subclavian and axillary arteries equals the entire cardiac output.

It is essential to use the proximal portion of the axillary artery rather than the distal segment. With the arm extended the proximal axillary artery is accessible just as it emerges from under the clavicle and is relatively fixed at this point so that motion of the anastomosis is less. Utilization of the distal one third may account for higher incidence of failures in some series.[26]

Fears that the patient might constrict the subcutaneous graft by tight clothing or direct pressure were groundless. Many patients continue to wear belts. Attempts to compress these grafts during arteriography show that it is difficult to produce sufficient pressure to impede blood flow.

Results

Results of subcutaneous grafting procedures are given in Table 1. Early graft failures are those lost within 3 months after placement. Most acute failures of grafts were due to technical inadequacies of the initial operation. It is mandatory to reoperate upon occluded grafts promptly since twisting or kinking, elevation of intimal plaques or narrowing are correctable. Operative angiography provides for recognition and immediate correction at the operating table. The incidence of immediate failure has fallen to a negligible level since

adopting this policy. Avoidance of vascular clamps to outflow vessels has prevented many technical failures related to crushing or elevation of plaques in diseased arteries.[5]

There were fewer late failures with femorofemoral grafts and combined axillofemorofemoral grafts than with axillofemoral grafts. This is probably because cross-leg grafts do not kink with flexion of the body, and are less disposed to disruption of the neo-intima. Failures in axillofemorals appear related to low flow due to progression of disease in outflow vessels. Combined grafts which have higher flows in the axillary segment may have a lower failure rate for this reason.

Bypass failure can be predicted by palpation of the graft during follow-up examination. When flow is high through the axillofemoral bypass, the graft is soft, thin and compressible and long-term function has been the rule. When flow rate is low, the graft becomes firm and the neo-intima is very thick. Most thick-walled grafts ultimately occlude. This is probably due to disruption of the neo-intima as suggested by Wesolowski,[27] or embolism of portions of thickened neo-intima disrupted at the sites of flexion. Some grafts have remained patent for prolonged periods even though flow is negligible.[2] This supports the contention that accidents to the neo-intima cause most of the closures, and the thicker the neo-intima, the greater the likelihood of accidents.[27]

Failure rate of these grafts compares with those of other bypass procedures. When the distal vascular system was normal, long-term patency was excellent, a patency rate of 80% after two years. When one or more outflow vessels are occluded, patency rate is lower as with femoropopliteal Dacron bypass grafts, 50% at 2 years. No deaths were due to operation *per se* but were related to the systemic diseases. Four deaths resulted from persistent intra-abdominal sepsis despite removal of the Dacron grafts. One death was due to progressive gas gangrene involving the opposite thigh and hip which was not controlled by disarticulation of the leg at the hip and massive debridement. Axillofemoral bypass was carried out in this patient in an attempt to improve blood flow beyond an aortic thrombosis. Two deaths in the femorofemoral series occurred in patients who developed ischemia of the leg following an acute myocardial infarct. Both deaths were due to progression of myocardial disease.

TABLE 1. *Subcutaneous Arterial Bypass*

Type of Graft	No. Patients	Postop. Deaths	Immediate Failure	Late Failure
Femorofemoral	19	3	1	4
Axillofemoral	31	3	2	11
Combined	10	1	1	2

One late death from ruptured aneurysm occurred amongst six patients who had combined grafts performed for aortic aneurysms. This patient was dyspneic at rest because of severe pulmonary emphysema. Bypass of a symptomatic aneurysm was performed without ligation. He died 1½ years later from rupture at the proximal portion of the unthrombosed aneurysm.

Summary

When operative repair of major intra-abdominal blood vessels is contraindicated because of associated medical disease, such as recent myocardial infarction or severe pulmonary disease, or when technical problems contraindicate the use of conventional grafts, subcutaneous arterial bypass procedures can revascularize the lower extremity with negligible risk. The only contraindications to subcutaneous arterial bypass are absence of an accessible proximally patent peripheral artery, such as the femoral or axillary, absence of major outflow vessels, or infection along the route of the proposed graft.

Sixty superficial bypass procedures were performed for aorto-iliac occlusive disease, aneurysm and infection. These included 19 femorofemoral grafts of which one was an immediate failure and four late failures. Thirty-one axillofemoral grafts were carried out, with two immediate failures and

11 late failures. Ten combined axillofemoral grafts were performed with simultaneous femorofemoral grafts to revascularize both lower extremities; there was one immediate failure and one late failure. All deaths occurred in patients who required emergency operations and the deaths were related to underlying diseases, such as intraperitoneal sepsis, gas gangrene and acute myocardial infarction.

Femorofemoral or iliofemoral bypass is an excellent procedure when the opposite iliac system is patent. In the absence of a patent iliac artery, the axillary artery provides inflow. Combined procedures consisting of axillofemoral bypass in conjunction with femorofemoral bypass have functioned well, presumably because of higher flows through this system. There have been no ischemic complications in extremities supplying inflow to these grafts, presumably because the normal axillary artery and femoral artery are large enough to supply flow equal to the cardiac output. Late failure of reconstructions were primarily in patients who developed outflow occlusions at the level of the femoral artery. When the vessels comprising the runoff system were normal the incidence of early and late failure was low.

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