SOME OBSERVATIONS ON RECONSTRUCTIVE ARTERIAL SURGERY IN ATHEROSCLEROSIS OBLITERANS OF THE LOWER EXTREMITIES

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Atherosclerosis obliterans is an ubiquitous disease sparing no organ or viscus. It is the commonest cause of mortality and is responsible for much morbidity such as strokes, cardiac failure and gangrene of the extremities.

The disease is widespread, tends to affect mainly the large and medium-sized arteries, and is commonly found in the lower extremities. The reasons for this are not known, but perhaps the higher arterial pressure in the erect position, and indirect trauma from muscular action may play a part. Although atheroma is usually found in the elderly and middle-aged, it may appear in the young adult. In fact, many cases of obliterative arterial disease in the young adult, which were previously ascribed to Buerger's disease, are now known to be due to atherosclerosis. Furthermore, there are some who do not recognize the existence of Buerger's disease and others who accept it with great reserve.

During the last decade or so the treatment of atherosclerosis obliterans of the lower extremities has undergone radical changes. Whereas, in the past, surgical treatment was usually indirect and the mainstay was sympathectomy, the emphasis is now on direct arterial surgery, reconstructing the affected artery by grafting or thromboendarterectomy.

With regard to the advisability of reconstructive arterial surgery in atherosclerosis, it has been argued that to operate on a patient suffering from a generalized disease is both irrational and unjustified. Although atherosclerosis is widespread, the thrombosis that complicates the disease and causes the symptoms is often segmental, has a predilection for certain arteries and may remain localized for a long time. It is because of this fortuitous behaviour that reconstructive arterial procedures either by grafting or thromboendarterectomy can be carried out with a good measure of success. The techniques of the reconstructive procedures are now fairly well standardized although the indications for such procedures are not universally agreed upon.

In the lower extremities, the commonest sites for occlusion are the femoro-popliteal and aorto-iliac areas. The disability arising from occlusion of the aorta and iliac arteries is usually a reduced exercise tolerance and impotence, but eventually there may be loss of limb. Thrombosis of the femoral and popliteal arteries usually presents with claudication and in the more advanced cases with rest pain and gangrene.

Since the advent of reconstructive surgery, sympathectomy has taken a secondary role since it cannot restore the circulation to the degree that can be accomplished by reconstructive surgery. Although sympathectomy undoubtedly enhances the circulation to the skin, its effect on muscle flow is questionable and the results of the operation for claudication are variable and unpredictable. Nevertheless it is a valuable procedure and should be carried out when reconstructive surgery is inadvisable or not feasible, as in small-vessel or widespread thrombosis. It is also a useful operation to supplement the effects of direct surgery either as an antecedent or concomitant procedure.

Since the introduction of the newer arterial reconstructive procedures sexual potency may be restored in some cases, intermittent claudication can be cured or relieved and gangrene averted or localized, thus limiting the extent of amputation. Until the aetiology of atherosclerosis is known and effective measures for its prevention undertaken, these recent methods are unquestionably great advances and are the best that can be offered to those affected by this disease.

Diagnosis of Atherosclerosis Obliterans

The diagnosis can usually be made on the history alone, common symptoms are intermittent claudication, rest pain and gangrene in order of frequency, and when the aorta and iliac arteries are occluded impotence may be an associated symptom.

The distribution of the claudicating muscle is not always an accurate guide to the localization of the arterial occlusion. The amount of work done by the muscle is also a significant factor determining the site of claudication. The calf muscle, for example, is a common site for claudication, because considerable energy may be expended in walking. Calf claudication may therefore be caused by an occlusion situated anywhere between the aorta and the tibial arteries. It is worth while to remember, too, that pain in the lower back or buttocks on exertion may be due to an aorto-iliac obstruction and that in any case of obscure back pain the lower limb pulses should always be examined. Many patients have been treated for disc lesions and have even undergone surgery when examination of the pulses would have disclosed the true nature of the condition. In the feet too, osteo-arthritis, metatarsalgia and flat feet should not be diagnosed until obliterative arterial disease has been excluded. Conversely it should not be forgotten that claudication-like symptoms may be produced by lesions of the cauda equina giving rise to the so-called neurogenic claudication.[1]

In the examination of the patient, the state of the pulses is most important. Although an absent pulse always signifies disease (except perhaps the dorsalis pedis where it may be congenitally absent), a palpable pulse does not necessarily exclude arterial disease. For example, in stenosis or occlusion of an iliac artery, the distal pulses may be present if there is a well-developed collateral circulation. If the lesion is unilateral the diagnosis will probably not be missed because there will be inequality of distal pulses. However, should both iliac arteries be narrowed, the decreased pulses may not be obvious and the diagnosis may be overlooked. On exercise, however, the distal pulses may disappear, thus indicating proximal arterial disease. Under normal circumstances the pulses remain the same on exercise, or they may be increased in amplitude.

Auscultation over major arteries is rewarding,[2] because the presence of a bruit invariably indicates turbulence in

blood flow, a result either of stenosis or dilatation. Bruits are often heard over the common femoral artery in the groin for the simple reason that this artery is most superficial. A murmur here is often conducted down the medial side of the thigh and may even be heard in the popliteal-fossa. Bruit may also be audible over the aorto-iliac area, and when the renal arteries are involved the bruit may be conducted into the flank. The temperature of the limb should be recorded, and for this to be accurate the extremities should be exposed to room temperature for at least 10 - 20 minutes before a final assessment is made. Therefore this test can be conveniently left until the end of the examination. Nutritional skin changes, pallor of the feet on elevation, rubor on dependency, and delayed venous filling time all indicate advanced ischaemia. Neurological defects should be noted; they are not uncommon in diabetes.

Oscillometry and the skin temperature response to reflex heating or lumbar block are useful tests but by no means essential for a clinical diagnosis. Highly specialized investigations such as blood-flow estimations, using venous occlusion plethysmography, are not necessary for a diagnosis and are used mainly for research purposes.

Apart from the clinical methods of diagnosis outlined above, the only special method of investigation and the one which yields the most important information is arteriography. Today almost any artery in the body can be outlined by the injection of a radio-opaque solution into the artery proximal to the occlusion, and the precise locality and extent of the block can usually be visualized. The information derived is of the utmost value and in most situations is essential if reconstructive surgery is to be carried out. Although the procedure is generally harmless, sometimes serious complications do occur and consequently the procedure should not be undertaken unless the indications for operation are present and the information is essential.[3] A situation in which arteriography is not mandatory is aorto-iliac disease. When the femoral pulses are absent or reduced and the abdominal aorta is palpable, aortography is not essential. If operation is indicated, examination of the arteries at laparotomy will reveal the extent of the disease.

Because atherosclerosis is a generalized disease it is of course necessary to carry out a full general examination to exclude cerebrovascular disease, coronary artery disease, renal disease and hypertension. The presence of atherosclerosis elsewhere no doubt alters the prognosis and may even militate against operation, but this does not necessarily contraindicate operation. A patient who has had a coronary thrombosis may yet have a useful lifespan ahead, and to deny him operation is unfair and unjustifiable. If a patient can withstand a major amputation he can usually tolerate a grafting procedure. On the other hand to operate on a man for mild claudication in the presence of angina is obviously unwise. The increase in walking tolerance achieved by a successful operation may predispose him to increased anginal attacks and possibly precipitate a fatal coronary thrombosis. In such a patient the claudication restricts his activity and by 'putting on the brake' protects his heart from undue exertion.

Diabetes should be excluded and if present should be treated as soon as possible. There is no difference between the atheroma of the diabetic and the non-diabetic, except perhaps that atheroma comes on earlier in the former and is more severe. However, the diabetic may suffer from an angiopathy of the skin vessels — a pathological condition distinct from atheroma — and this accounts in part for the gangrene of the toes that occurs in the presence of ankle pulses. It must be borne in mind, however, that gangrene in diabetes is not always caused by arterial ischaemia but may be due to infection or neurotrophic causes. In the latter instance minor trauma or extreme ranges in temperature are not appreciated because of impaired sensation, and thus tissue damage may occur in spite of good pulses.

TYPES OF RECONSTRUCTIVE ARTERIAL PROCEDURES

The arterial circulation may be restored by either thromboendarterectomy or grafting. Whichever procedure is employed it is essential that the host artery above and below the obstruction should be free from gross disease; obstruction to the flow of blood through the reconstructed segment of artery either through poor inflow or outflow (run-off) predisposes to stasis and re-thrombosis.

(a) *Thromboendarterectomy*

In this operation first described by Dos Santos,[4] the diseased intima and associated thrombus are removed leaving part of the media and adventitia. A new smooth wall channel is thus created. The opening in the artery through which the diseased portions are removed may be made through a longitudinal incision along the entire course of the thrombosed segment, or the artery may be opened proximal and distal to the diseased area and the thrombus removed by the semi-open method using arterial ring strippers.

The advantages of thromboendarterectomy are that occluded collaterals may be re-opened and the possibility of infection is reduced because no foreign material is introduced apart from the sutures. A graft or prosthesis should always be available, however, should thromboendarterectomy not be feasible. The operation is best suited to localized obstructions of the larger arteries and should not be performed in dilated arteries or those heavily impregnated with calcium deposits. Both signify extensive arterial degeneration in which case a graft is preferable.

(b) *Grafting*

There are 2 methods of grafting: the occluded segment may be excised and the continuity restored by graft, or the affected area may be left *in situ* and bypassed.

In the initial stages of the modern era of reconstructive arterial surgery, thrombosed arteries in the limb were treated by excision of the affected segment and the graft anastomosed to the host artery above and below by an end-to-end suture. The results of this procedure were not satisfactory because the rate of postoperative thrombosis was high. Several factors were responsible. The artery distal to an area of thrombosis is often small so that an adequate size anastomosis with the graft was difficult to construct, resection of the artery was difficult because of adherence to the concomitant vein which was liable to damage, and because collaterals on which the nutrition of the limb depended were often sacrificed. Thus, if the graft occluded, the condition of the limb was often worse after the operation than before. In the aorta and iliac arteries, however, resection and grafting by end-to-end anastomosis is satisfactory because of the larger diameter of these vessels.

Dissatisfaction with the results of resection and grafting in the limb led to the adoption of the bypass procedure.[5, 6] In this operation the thrombosed segment is left *in situ* and the obstructive segment bypassed with a graft which is anastomosed to the patent host vessel above and below by an end-to-side anastomosis. The size of the anastomosis is not limited by the diameter of the host artery and a site can usually be chosen which is relatively free of disease. Few, if any, collaterals are disturbed and in fact the graft acts as an additional collateral.

In the peripheral vessels the grafts in common use today are prostheses and saphenous vein autografts. Homografts have been largely discarded because of the difficulty in procurement, sterilization, preservation and the degenerative changes which follow implantation leading to thrombosis and aneurysmal formation. Prostheses of various kinds are being widely investigated and used and have largely replaced the arterial homograft. Their use has been proven in the large arteries, but the results in the small arteries are far from satisfactory. The advantages of prostheses are many. They are easily procured and sterilized and artery banks together with the problems of sterilization and preservation have been dispensed with. At present dacron and teflon prostheses appear to be the best. They cause little tissue reaction and do not lose much of their tensile strength after implantation. Most prostheses are now crimped to increase their elasticity and flexibility to avoid kinking when they cross a joint. However, following implantation and with the ingrowth of fibrous tissue into the interstices of the graft, there is little doubt that these mechanical advantages evident *in vitro* are not present *in vivo*. The patient's own saphenous vein is probably the best graft, because being an autograft it lives. Its use is limited, however, because long segments of vein of adequate diameter throughout are not always available. The patch graft or lateral patch, a relatively recent innovation, is of great value in the localized stenosis where the artery can be widened without resection. It is also useful after thromboendarterectomy where the diameter of the blood-vessel is small.

INDICATIONS FOR SURGERY IN ATHEROSCLEROSIS OBLITERANS OF THE LOWER EXTREMITIES[7]

(a) *Incipient or Established Gangrene*

Except in patients with massive gangrene of the foot or leg, no limb should be considered for amputation until an arteriogram has shown that the reconstructive arterial procedure is impossible. Gangrene of a toe or the dorsum of the foot can be induced to separate with subsequent healing of the tissues by a graft.

(b) *Rest Pain*

In the absence of local sepsis or gangrene, rest pain is a symptom of severe ischaemia and, if persistent, gangrene will usually occur. Sometimes rest pain occurring after a recent arterial thrombosis will ease with conservative treatment as the collateral circulation develops, but more often the pain persists and gets more severe and a grafting operation should be performed if anatomically possible.

(c) *Intermittent Claudication*

This is the commonest symptom of atherosclerosis. Numerous therapeutic methods for relieving the symptom have been tried with varying success. Sympathectomy is of questionable value because, although the skin flow is augmented, the blood flow to muscles is not significantly improved. Since the introduction of reconstructive arterial procedures, it has become possible to re-establish arterial continuity and thus restore blood flow to both skin and muscle to a degree not achieved by any other method. Patients whose livelihood is jeopardized or whose activity is severely restricted are accepted for operation, provided they have no serious coronary, renal or cerebral disease. Mild claudicants are not accepted because their symptoms may remain stationary and in some cases may even improve considerably with the development of further collaterals.

CLINICAL MATERIAL

The clinical material comprising this study consisted of 273 patients suffering from atherosclerosis obliterans of the lower extremities who were admitted for treatment to the Professorial Surgical Unit during a 5-year period ending June 1964.

The patients were all indigent and were admitted to the unit from the Peripheral Vascular Clinic, medical units or directly from casualty in acute emergencies. Of this group only 75 (27%) patients were considered suitable for vascular reconstruction. The indications for advising reconstructive surgery in this group were: (1) a threat to the limb or (2) severe intermittent claudication. In the large remaining group reconstructive surgery was not done in the following cases: (1) patients who already had extensive gangrene and who required a major amputation, (2) those patients with severe cardio-respiratory disease, (3) patients with moderate claudication only and (4) patients in whom surgery was precluded on the basis of arteriography or the findings at operation. The diagnosis of atherosclerosis was based on the histological findings on tissue removed at operation.

PRINCIPLES OF TREATMENT

In acute arterial occlusion a brief period of conservative treatment was always carried out because in many patients an efficient collateral circulation will develop and the limb will not proceed to gangrene. Furthermore, by delaying operation a better general assessment of the patient can be made. Many of these patients have cardio-respiratory disease, are elderly and thus poor surgical risks. Some have cardiac failure and the condition of the limb may be of secondary importance. During the period of conservative treatment, which in the main consisted of systemic heparinization and elevation of the head of the bed to increase the perfusion pressure in the lower extremities, the progress of the limb was carefully observed, and the patient's general condition assessed. If after a period of 2 - 3 hours of observation the condition of the limb deteriorated, arteriography was carried out, in most cases of femoro-popliteal occlusions and occasionally in aorto-iliac obstructions, to determine the feasibility of direct arterial surgery. If reconstruction appeared possible, operation was carried out as an emergency. In patients with ischaemia of insidious onset or in whom there was no threat to the limb, operation (if indicated) was done as an elective procedure after careful general assessment and arteriography.

Although the predominant sites of occlusion were the aorto-iliac and femoro-popliteal regions, in many patients, and especially those suffering from severe ischaemia, there were combined lesions. In the combined aorto-iliac and femoro-popliteal occlusions, reconstruction was limited in the first instance to the proximal occluded segment. Provided the profunda femoris artery is patent, and fortunately this artery is often patent, the increased flow through this vessel, which is often achieved after reconstruction of the proximal occluded segment, is generally sufficient to augment the collateral circulation around the more distal femoro-popliteal occlusion so as to prevent gangrene or cure or relieve claudication.

In the 75 patients subjected to direct arterial surgery, 50% had associated disease such as cardiac involvement (previous coronary thrombosis, angina or ECG changes), hypertension, diabetes, polycythaemia and uraemia. In this group 102 reconstructive limb operations were done—in 90 limbs as a primary procedure and in 12 limbs as a secondary or tertiary procedure following re-occlusion or extension of the disease. Nine patients (12 reconstructed limbs) were lost to the follow-up and have not been in-

cluded in the results. A total of 90 reconstructive limb operations were then available for assessment.

Tables I - IV show the areas of reconstruction*, the type of procedure, the indications for operation and the results of surgery. There were 45 (50%) reconstructions in the aorto-iliac common femoral area or above the profunda artery level, and 45 reconstructive procedures in the femoro-popliteal or below the profunda femoris level. Thromboendarterectomy was the commonest procedure in the aorto-iliac area, whereas autogenous saphenous vein grafting was the commonest procedure in the femoro-popliteal area. The indications for surgery were severe claudication in 50% of patients and a threatened limb in the remaining 50% of patients. In aorto-iliac reconstructions sympathectomy was usually carried out concomitantly and was occasionally done in the femoro-popliteal reconstructions.

*Although some of the reconstructions in the aorto-iliac regions extended to the femoral region, for the sake of simplicity and at the expense of slight accuracy, they were classified as aorto-iliac reconstructions.

TABLE I. SEVERE CLAUDICATION

		Aorto-iliac		
	No.	*Immediate*	*Early (1-12 months)*	*Late (1-5 years)*
Endarterectomy	19	19 (100%)	17 (89·4%)	13 (68·4%)
Prosthesis	4	4 (100%)	1 (25%)	0
Vein graft	—	—	—	—
Homograft	2	1 (50%)	1 (50%)	0
Total	25	24 (96%)	19 (76%)	13 (52%)

TABLE II. SEVERE CLAUDICATION

		Femoro-popliteal		
	No.	*Immediate*	*Early (1-12 months)*	*Late (1-5 years)*
Endarterectomy	4	4 (100%)	1 (25%)	1 (25%)
Prosthesis	6	5 (83·3%)	2 (33·3%)	0
Vein graft	8	8 (100%)	6 (75%)	4 (50%)
Homograft	2	1 (50%)	1 (50%)	0
Total	20	18 (90%)	10 (50%)	5 (25%)

TABLE III. THREATENED LIMBS

		Aorto-iliac		
	No.	*Immediate*	*Early (1-12 months)*	*Late (1-5 years)*
Endarterectomy	16	12 (75%)	11 (68·9%)	9 (56·3%)
Prosthesis	2	1 (50%)	0	0
Vein graft	1	1 (100%)	1 (100%)	1 (100%)
Homograft	1	1 (100%)	1 (100%)	0
Total	20	15 (75%)	13 (65%)	10 (50%)

TABLE IV. THREATENED LIMBS

		Femoro-popliteal		
	No.	*Immediate*	*Early (1-12 months)*	*Late (1-5 years)*
Endarterectomy	6	4 (66·7%)	3 (50%)	2 (33·3%)
Prosthesis	6	3 (50%)	2 (33·3%)	1 (16·6%)
Vein graft	12	8 (60·6%)	6 (50%)	3 (25%)
Homograft	1	0	0	0
Total	25	15 (60%)	11 (44%)	5 (20%)

RESULTS

A reconstruction was classified as successful if there was a prompt return of a pulse distal to the site of reconstruction *and* a rapid improvement of severe ischaemic changes in the limb, such as relief of rest pain, early localization of gangrene and healing of ulcers. The results have been classified into three groups: (a) *Immediate*, where the patient has been discharged with a patent reconstruction, (b) *early*, where patency has been maintained for at least a year; and (c) *late*, where patency was maintained for 1 - 5 years or more. The results differed according to the site of reconstruction, the type of reconstruction and the degree of ischaemia (Tables I - IV). Follow-up ceased when the reconstructed segment occluded or the patient died.

In aorto-iliac reconstructions for claudication the total immediate success rate was 96% and where the procedure was a thromboendarterectomy the immediate success rate was 100%. Of all the reconstructions 76% were patent for at least a year and 52% were patent for periods varying between 1 and 5 years. In the latter group about half were patent for 3 - 5 years. Where thromboendarterectomy had been carried out 68% of reconstructions were patent for periods up to 5 years.

In the femoro-popliteal area the immediate success rate for claudication was 90%, the early success rate was 50%, and the late success rate 25%. However, where autogenous vein grafts were used, the immediate patency rate was 100%, the early patency rate 75% and the late patency rate 50%. Arterial procedures, where the indication for surgery was a severely threatened limb, were not materially different.

The operative mortality was 2·75%. One patient died of a cerebrovascular accident and the other of a pulmonary embolus. Both patients had failed reconstructions for incipient gangrene and died after major amputations. Subsequently 9 patients died at intervals of from 5 months to 5 years, 5 from cerebral and cardiac disease, 4 from non-vascular disease such as Hodgkin's disease, carcinoma of the lung and gastrointestinal bleeding.

Amputations

Twelve limbs were amputated in the postoperative period because of failure of the reconstruction. The indication for surgery in this group was incipient gangrene in all, 8 in the femoro-popliteal region and 4 in the aorto-iliac region. A further 11 limbs subsequently came to amputation after periods ranging from 3 to 18 months. The original indication for surgery in this group was severe ischaemia in 8 limbs, 7 of which were in the femoro-popliteal regions. Four limbs came to amputation when the original operation was done for claudication.

Of those limbs whose reconstructed arteries occluded but did not come to amputation, improvement in many was maintained. Although they have been classified as failures for the record, this does not necessarily mean that the operation has been unsuccessful, e.g. amputation for a gangrenous lesion of the foot may be averted by a reconstructive procedure, and subsequently thrombosis may occur without the reappearance of gangrene; a period of augmented blood flow will produce healing which may persist after occlusion of the reconstructed segment if this has been gradual. Such results should be regarded as successful since the limb has been saved.

DISCUSSION

The success rate in reconstructive arterial surgery, apart from technical considerations, depends on the site and extent of the occlusion and the type of reconstructive procedure. In the aorto-iliac area, where the vessels are big, the immediate success rate was higher than in the smaller femoro-popliteal areas. Larger vessels are easier to repair and, should slight narrowing occur, the volume flow is not materially reduced. In vessels with smaller diameters, how

ever, an equal degree of narrowing causes a proportionately greater reduction in blood flow (Poiseuille's Law) and reduction in flow rate predisposes to stasis and thrombosis. However, in the long run, the success rate was not significantly different in the 2 groups. The extent of the occlusion has also a significant influence on the outcome. In the claudicating limb, the site of occlusion is often single and localized and is more amenable to reconstructive arterial surgery than in the threatened or pregangrenous limb where there are often multiple occlusions. The type of procedure, too, has a bearing on the success of surgery. In the aorto-iliac area we have found thromboendarterectomy very gratifying and have had good results with this procedure. We prefer the open method of thromboendarterectomy to the semi-closed loop stripper method, because a 'cleaner' endarterectomy can be carried out by the open method. It is not necessary to suture the intima to the arterial wall to avoid intimal flap dissection if the endarterectomy is continued distally to a relatively normal artery. Occasionally when the reconstructed artery appears to have been unduly narrowed, a patch graft of saphenous vein to widen the vessel has been found to be most useful. We do not use prostheses for occlusive disease in the aorto-iliac area except of course when a thromboendarterectomy is not feasible by virtue of the artery being too small, calcified or aneurysmal. Few homografts were used in this series and were discarded early on. The difficulty in procurement, sterilization and preservation, and late complications, such as thrombosis and dilatation, have led to their being abandonded.

In the femoro-popliteal region if the occlusion is localized, thromboendarterectomy — combined, if necessary, with a saphenous vein patch graft — is a satisfactory procedure. In extensive occlusions we prefer the patient's own saphenous vein as a bypass graft and have had the best results with this material. Occasionally there was insufficient length of adequate vein and this difficulty was overcome by thromboendarterectomy of the proximal part of the occluded segment and completed distally with a shorter segment of vein. The length of the vein graft has not apparently had any adverse effect on the success of the procedure and we have several vein grafts 40 cm. and more in length functioning for more than 4 years. We have not favoured prostheses in the femoro-politeal region because of their disappointing long-term results. However, they have been used when a vein graft or thromboendarterectomy has not been possible, or when we wished to avoid a long and extensive procedure in an elderly poor-risk patient.

In patients with multiple levels of occlusion, and this was often found in those suffering from severe ischaemia, the policy was usually to revascularize the proximal occluded segment only. Many patients were sub-standard risks and we felt unjustified in extending the reconstruction from the aorto-iliac area, especially if both limbs are involved, to the popliteal regions either by thromboendarterectomy or grafting. In combined aorto-iliac and femoro-popliteal occlusions disobliteration of the proximal segment with revascularization through the profunda femoris was often sufficient to increase the collateral blood flow around the residual distal occlusion. In most cases this was sufficient to ensure the viability of the limb, to allow gangrenous areas to be amputated with primary suture and to allow ulcers to heal promptly. In cases where the distal circulation was insufficiently augmented by this procedure, femoro-popliteal reconstruction was subsequently carried out. If this was not possible, the primary procedure was still worth while because it enabled a below-knee amputation to be carried out instead of the usual above-knee amputation.

With regard to sympathectomy, we feel that it is a valuable adjunct and almost invariably do it at the time of aorto-iliac reconstruction. With the decrease in peripheral arteriolar resistance, which follows sympathectomy, the flow rate through the reconstructed segment is increased, thereby contributing towards the patency of the reconstructed segment.

The patient mortality was 2·7% and the operative mortality 2·2% (2 deaths per 90 operations). This is an acceptable mortality rate considering that many of these patients are elderly with generalized atherosclerosis. Because the over-all mortality of above-knee amputations is about 20%,[8] we feel that if a patient can withstand a major amputation he can tolerate a major arterial procedure. Two patients developed sepsis. In one a secondary haemorrhage occurred at the proximal anastomosis of a homograft in a femoro-popliteal reconstruction which was inserted for incipient gangrene of the foot. The femoral artery had to be ligated and the limb subsequently amputated. In the second patient infection developed around an ilio-femoral prosthesis that had been inserted for claudication. A false aneurysm resulted and was treated by ligation of the common iliac artery and removal of the prosthesis. The claudication was not worsened.

With regard to the 12 limbs that were amputated in the immediate postoperative period, the indication for surgery was impending gangrene. Although surgery was followed by amputation, it is felt that there was no great loss. This group of patients all had rest pain and surgery merely hastened the final event.

The failed reconstructions can be divided into 2 groups, those that failed early and those that failed late. The early failures we feel were due to a combination of technical faults and poor vessels. These occurred mainly in the femoro-popliteal areas and particularly where there was a poor run-off. The late failures were probably caused by both technical faults and progression of the disease. There can be little doubt that progression of the disease is a significant factor. This is borne out by several of our patients who had recurrent ischaemia which on arteriography revealed new sites of occlusion away from sites previously reconstructed. Atherosclerosis is a progressive disease and surgery does not in any way alter the basic pathology. Although anticoagulants were used during the operation, long-term anticoagulants were not used as a routine after operation. As yet we have no firm convictions about the value of anticoagulants after reconstructive arterial surgery because there is no correlation between the failure or success rate and anticoagulation.

With regard to the indications for direct arterial surgery we feel that it is indicated primarily for the severely ischaemic limb characterized by rest pain, indolent ulceration and impending or frank localized gangrene. In patients with gangrene of a toe, for example, healing of the stump

after amputation may not occur and a higher amputation may have to be carried out. After successful restoration of the circulation, gangrenous areas become rapidly localized and amputation can be carried out assured of either primary suture or secondary healing. In several patients in the series who presented with localized gangrene, healing occurred after direct arterial surgery. Subsequent re-occlusion occurred in a few limbs, but gangrene did not reappear. Although they have been classified as failures of reconstruction, they should be regarded as successes because the limb was still saved. Claudication was not an absolute indication for reconstructive arterial surgery unless the patient was severely handicapped. It was the type of activity engaged in by the patient rather than the claudication distance which counted. For example, a retired elderly patient with a claudication distance of 50 yards did not qualify for surgery whereas claudication in a postman at a distance of 200 - 300 yards, for example, did. It should be remembered, too, that the outlook with regard to limb survival in a patient suffering from claudication is good; not more than about 10% will proceed to gangrene.[9]

The diagnosis of arterial occlusion can be made on the history alone and in many patients confirmed on clinical examination. Arteriography is done only when surgery is indicated and should not be carried out to confirm the diagnosis. Although the procedure is harmless in the majority of instances, complications do occasionally occur, some of which are serious.

SUMMARY

1. The results of 90 reconstructive arterial procedures in 75 patients suffering from atherosclerosis in the lower extremities are reported over a 5-year period.
2. The indications for surgery were either incipient gangrene or severe claudication.
3. The mortality rate was 2·7%.
4. The procedure of choice was thromboendarterectomy in the aorto-iliac area. In the femoro-popliteal area vein grafts gave best results for long occlusive segments.
5. Until the basic cause of atherosclerosis can be treated, direct arterial surgery is the best that can be offered to patients suffering from this disease.
6. No limb should be amputated unless an arteriogram has shown that direct arterial surgery is not feasible or gangrene is extensive.

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