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FEMORO-POPLITEAL ARTERIAL OBSTRUCTIONS

LATE RESULTS OF TEFLON PROSTHESES AND ARTERIAL HOMOGRAFTS

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The treatment of ischaemic disease of the legs due to thrombo-obliterative disease of the femoral and popliteal arteries by restorative procedures, by-passing or removing the obstruction, has been in use for several years. In this centre this type of disease in suitable cases has been treated by the by-pass operation, and endarterectomy has been but little used until recently.

This paper concerns two periods in the direct surgical treatment of this disease: the first from 1953 until 1959, when freeze-dried homografts were used; the second from early 1960 to date, when woven or knitted crimped "teflon" tubes 5/16 in. (8 mm.) in diameter were inserted. Forty-six patients had restorative surgery; three had bilateral procedures, and two had a repeat graft, making a total of 51 by-pass operations. There were two operative deaths, and two patients could not be traced.

Selection of Cases

We have had no cause to liberalize our criteria for operation in these cases, since they were stated by Ashton and Rains (1960); indeed, we are if anything more conservative. Claudication alone is not considered to be an indication for operation unless it is crippling—that is, it comes on after walking less than 50 yards (46 metres). A lesser degree of claudication may in rare cases be accepted when it is seriously interfering with the patient's occupation. Rest-pain, ulceration, and

impending or frank gangrene were the reasons for operation in 41 (89%) of our cases.

Any success, however limited, in the latter group represented a positive gain, since the alternative was early amputation; and from the point of view of limb survival nothing, therefore, was to be lost by attempts at grafting, whatever the outcome. The age of the patients varied from 31 to 74 years, the greatest number (23) being in the sixth decade.

Duration of Symptoms.—The duration of symptoms varied from six weeks to six years, with an average of two years. Those patients whose symptoms had existed for only a short time usually had gangrene of the extremity. Those whose history was longer had claudication as a principal symptom, surgery being precipitated by the onset of the more clamant symptoms of rest-pain, gangrene, or claudication after a few steps.

Concomitant Disease

Six patients had diabetes—two with coronary-artery disease. One operative death occurred in this group; in the remaining five, two grafts are still open at three years and 18 months after the operation.

Eleven patients had arterial hypertension—that is, a diastolic pressure of over 100 mm. Hg. Three of these grafts are still open. There was one operative death in this group, and one patient has since died.

Electrocardiographic Changes.—Patients with obliterated arterial disease in the legs are likely to have similar generalized disease to a greater or less degree. Though only three patients showed an ischaemic pattern on E.C.G., two of these died as a result of the operation, showing how adversely this factor may affect the prognosis.

Arteriography

It has been the practice in this unit to perform aortography, preferably by retrograde femoral catheterization, in every case where femoro-popliteal grafting is considered. Besides providing information about the nature and extent of the blockage in the superficial femoral artery, we feel it is of prime importance to know about the degree of patency of the iliac vessels, which in the event of grafting govern the flow into the graft. It is not always possible to judge the patency of the iliacs by the magnitude of the femoral pulse in a resting limb, and if iliac disease is present it may be necessary to attach the graft to the common iliac artery or aorta above the obstruction.

Radiographic assessment of the patency of the popliteal artery is preferable to direct exploration, a procedure which carries risk to the limb by damaging collateral vessels if grafting is not possible. Furthermore, while the state of the tibial vessels can be roughly ascertained by the amount of back-bleeding on opening the popliteal artery it cannot be accurately known without arteriography with delayed films—retarded sufficiently to allow the vessels in the most ischaemic limb time to fill.

The Operation

In most cases the upper end of the graft was sewn end-to-side to the common femoral artery. If there was severe disease of this vessel a localized endarterectomy was carried out, and prior to anastomosing the graft an opportunity was taken to clear out the origin of the profunda femoris artery. There is now good experimental and clinical evidence that this latter step may

increase the blood supply to the leg should the graft fail (Laufman, 1960; Warren *et al.*, 1961). If arteriography showed severe disease of the iliacs then the graft was taken higher to the common iliac or the aorta (four cases). In this event it is desirable to perform a side-to-side anastomosis between the graft and the common femoral artery opposite the origin of the deep femoral artery, since this increases the "run off" of the graft and helps to maintain its patency. It also increases the blood flow to the limb, and, should the lower graft clot, the limb may still be saved, as the upper portion of the graft may remain patent, perfusion being maintained through the deep femoral artery. In a few cases the upper end of the graft was anastomosed to the superficial femoral artery above the block.

The lower site of anastomosis varied among the series and has been conditioned by the desire to avoid the graft crossing the knee-joint, thus preventing kinking, and the reasonable feeling that if the upper popliteal artery is at all diseased it would be better to by-pass it. This has resulted in some grafts being joined to the upper popliteal artery and some to the lower end just above the bifurcation.

Results of Operation

We classified the results strictly as successful if distal pulses were palpable and unsuccessful if none were felt, even though there might be substantial improvement in the patients' symptoms. The latter patients were regarded as therapeutic successes even if technical failures, since subjectively they were greatly improved even though distal pulsations were absent and the claudication distance might be trebled or quadrupled. Rest-pain was abolished and trophic lesions were healed, while the graft was patent and often did not reappear when it thrombosed. Furthermore, in certain patients with multiple distal occlusions it is impossible to restore pedal pulses even though satisfactory proximal perfusion is obtained.

Of 24 teflon tubes inserted 22 failed within a period of 20 months and two are still functioning. Of 23 homografts inserted 11 failed over a period of eight years and 12 are still functioning; of these 12, four became aneurysmal. One of the latter has been replaced and is functioning. Of the failures from both groups 13 patients remained substantially improved in their symptoms. Of the remainder, 15 limbs were amputated for intolerable rest-pain or frank gangrene and five other patients had a return of severe symptoms but have so far kept their legs (Table I).

TABLE I.—Duration of Follow-up

	Failure		Success	
	Homograft	Teflon	Homograft	Teflon
-1 month ..	5	13	1	
1-6 months ..	2	5		
7-12 " ..		3		
1-year ..	3	1	1	2
2-years ..	1		6	
3- " ..			2	
4- " ..			1	
5 " ..			1	
Total ...	11	22	12	2

If all those patients whose symptoms improved are included in the successes, then of the 24 teflon grafts 12 (50%) were successful and of the 23 homografts 15 (65%) were successful; over the whole series 27 (58%) were successful.

Effect of Sympathectomy on Patency of Graft and Survival of Limb

Twenty legs were sympathectomized—seven prior to grafting, seven at the time of grafting, and six after grafting (Table II); the latter six sympathectomies were

TABLE II

	Those Patients Having Lumbar Sympathectomy in Addition to Graft				Those Patients not Having Lumbar Sympathectomy in Addition to Graft			
	Suc-cess	Failure			Suc-cess	Failure		
		Imp.	Amp.	Same		Imp.	Amp.	Same
Prior to graft ..	3	3	1	—				
With graft ..	—	2	4	1				
After " ..	—	2	2	2				
Total ..	3	8	6	3	11	5	9	2

Imp. = Improved. Amp. = Amputation.

performed for ischaemia after the graft had clotted. In seven legs sympathectomized prior to grafting this resulted in three patent and four blocked grafts; of the four unsuccessful limbs three were improved symptomatically and one was amputated. Of seven legs sympathectomized at the time of grafting all the grafts blocked: four legs were amputated, two were improved, and one was as before. Thus of 14 legs that were sympathectomized either before or during grafting the grafts blocked in 11; of these five remained improved compared with their original pre-operative state, five were amputated, and one remained as before.

These results should be compared with those in the 27 patients in whom grafting was the only procedure; 11 grafts remained patent and 16 grafts blocked. In the latter group, nine legs were amputated, five legs were improved, and two were unchanged. While the number of cases is small, it does appear that sympathectomy has a deleterious effect on graft patency, but that its effect on limb survival may be beneficial if the graft should fail. In the group of six failed grafts having subsequent sympathectomy two cases were improved, two were as before, and two had amputations; this group has, of course, been excluded when considering the effect of sympathectomy on graft patency.

Effect of Anticoagulants

Some of the patients were given phenindione 24-36 hours post-operatively to bring their prothrombin percentage down to 30 or below, and this routine has been continued indefinitely in these patients. Systemic heparin has not been used.

Phenindione was given post-operatively to 22 patients, in whom 5 grafts are still patent and 17 have closed (Table III); of the latter, 11 showed continued improvement in their symptoms compared with their condition pre-operatively, four limbs were amputated, and two were unchanged. Among the patients who did not

TABLE III

	Patients Taking Phenindione				Patients not Taking Phenindione			
	Suc-cess	Failure			Suc-cess	Failure		
		Imp.	Amp.	Same		Imp.	Amp.	Same
Homo ..	4	2	4	2	8	1	6	2
Teflon ..	1	9	4	2	1	1	5	1
Total ..	5	11	4	2	9	2	11	3

Homo = Homograft.
Teflon = Knitted or woven teflon prosthesis.

receive phenindione 9 grafts were successful, but of the 16 failures only two showed improvement in their symptoms compared with the pre-operative state; in three the symptoms were much the same as before grafting, but 11 of the legs in which the grafts failed and no phenindione was given were amputated.

These results do not indicate that grafts in patients given anticoagulants are more likely to thrombose; for other factors, such as the nature of the graft, come into consideration (most anticoagulated patients had teflon prostheses) and most of the earlier homograft recipients did not receive anticoagulants. However, phenindione does appear to have a significant protective effect on the survival of those limbs in which thrombosis in the graft occurs.

Effect of Limb Perfusion during Insertion of Graft

Nine legs were perfused by the method described by Ashton and Rains (1960). Of these, five grafts remain patent, and this number includes the only two teflon prostheses remaining patent in the whole series. Of the failures in which grafts were implanted with the aid of this technique one was due to sepsis, one was because of the destruction of the peripheral vessels due to an old compound fracture, and the other two failed at 18 months and three months for no apparent reason. One of these legs remained improved and the other was amputated.

Value of Second Operations

A second operation has been attempted seven times—six for graft occlusion and once for graft aneurysm, the latter case being successful. There were four failures to restore flow, followed by amputation. Two of the attempts were successful; the graft in one of these patients has subsequently occluded but the leg is symptomatically improved. One re-graft is still patent.

Subsequent Fate of Patients

Two patients have died after discharge from hospital—one from a myocardial infarct; the cause of death in the other is not known.

One patient has developed angina pectoris and another has had a non-fatal coronary occlusion.

Discussion

On the whole the enthusiastic reports on the success of femoro-popliteal by-pass grafts in North America have not been confirmed by general experience in this country. Indeed, it is the prevalent pessimism concerning this subject that has caused us to be so strict in our criteria for case selection. De Bakey *et al.* (1958) reported 317 femoro-popliteal occlusions treated surgically by by-pass grafting with an initial success rate of 89%; of the 289 initial successes, 41 subsequently failed and 22 were re-grafted successfully. These workers commented that amputation would ordinarily have been required in only 20% of their patients, so it appears likely that their operative criteria are much wider than ours, since 89% of our cases were of this type.

In a subsequent communication Crawford *et al.* (1960) reported an immediate success rate of 85% in 83 cases treated with homografts, but of 37 cases followed for 24–66 months 52% failed. In 356 cases of femoro-popliteal occlusion treated with a knitted "dacron"

prosthetic by-pass the immediate success rate was 91%, falling to 75% at two years. In both series of those cases in which the graft had failed and a further operation was performed this was successful in approximately 90% of cases. These workers also observed that in many instances where the graft failed the limb remained symptomatically improved, as we have noted in our patients. Initially it was our policy to re-explore all the grafts that failed and attempt a second grafting procedure. This has been attempted six times, but only one of these re-grafts remains patent and we have now abandoned it as a routine procedure.

Whitman *et al.* (1961) reported a success rate of 69% using teflon by-pass prostheses, but their longest follow-up was only 22 months and almost half their cases had been operated on for one year or less. Furthermore, their main indication for operation was intermittent claudication of moderate severity where the survival of the limb was not threatened, and only in a few cases was operation undertaken as a last effort to save a grossly ischaemic limb.

Edwards (1960) described his experiences with 125 femoro-popliteal grafts using crimped tubes of braided nylon and knitted or woven teflon. The acute failure rate was 10%, and at two years 50% of the surviving grafts had occluded, giving a total failure of 60%; the rate of failure was the same whether the graft terminated above or below the knee. Edwards also quotes Szilagyi's experience using helanca dacron tubes, where the late failure rate was 40%. Edwards is of the opinion that many of the failures can be ascribed to physical defects in the prosthesis. This is also our view; such factors as loss of resilience, lengthening and buckling of the graft, and variations in the thickness of the neo-intima must have a very deleterious effect on the flow through the graft. Despite their eminence in this field we cannot agree with the De Bakey group, who are strongly of the opinion that the majority of late failures are due solely to technical faults. Some support for our view is obtained from the recent studies of Bellman and Löfström (1961), who investigated the stretching and twisting defects of woven teflon tubes of varying diameter when subjected to pressures of 160 mm. of mercury.

It is our opinion that many of the apparently conflicting reports on the success or otherwise of femoro-popliteal by-pass grafting can be explained by varying standards of case selection. If our criteria for operation were extended to claudication at 400 yards (365 metres) or so it might be that our percentage of successes would be substantially improved. However, bearing in mind the risks of grafting and the natural history of claudication, we do not consider by-pass grafting for symptoms of this order a justifiable procedure at the present time, and we prefer to reserve it solely for the treatment of those limbs where the patient is so severely incapacitated that amputation is the only practical alternative.

In the light of this experience we consider that plastic teflon tubes are not satisfactory prostheses for by-passing long occlusions in the femoro-popliteal region. Freeze-dried homografts, on the other hand, stay patent for longer periods. However, if they are to be used extensively the difficulties of acquisition and preparation present problems which do not occur when plastic grafts are used. Furthermore, some 30% of these grafts subsequently become aneurysmal, requiring further surgery.

Anticoagulants such as phenindione, while having no effect on graft patency, may have a distinctly beneficial influence on the survival of the limb should the graft thrombose. The effects of sympathectomy appear uncertain, but if there is any beneficial effect it is on limb survival after graft occlusion. Sympathectomy does not favourably influence graft patency.

There is a continued striking improvement in the clinical state of many of the legs even when grafts have occluded, as shown by the disappearance of previously palpable pedal pulses. That is to say, limbs that are technical failures remain therapeutic successes. The reason for this is not clear, but to some extent the improvement may be due to increased perfusion of the deep femoral artery following the clearing of the origin of this vessel prior to implanting the upper end of the graft. Despite these apparently disappointing results it must be stressed that they do represent salvage surgery. Forty-one of the patients had rest-pain, ulceration, and impending or frank gangrene; amputation was therefore the only practical alternative treatment in most of them. In fact, only 15 limbs were subsequently amputated, this giving an overall salvage rate of 65%. The majority of these latter patients either have a limb with palpable pedal pulses or one showing marked symptomatic improvement over its pre-operative state. Viewed in this light we believe that the surgical treatment of this increasingly common affliction well merits further endeavour.

Summary

The late results of homografts and prosthetic grafts in the management of femoro-popliteal occlusion are compared.

Of 23 homografts followed for periods up to eight years 12 are still functioning. Four of the latter became aneurysmal and one has been replaced and remains functional.

Of 24 teflon tubes inserted, 22 failed within a period of 20 months; two are still functioning.

The effects of phenindione and sympathectomy on graft patency and limb survival are discussed.

The "salvage" rate of limbs otherwise doomed to amputation was 65%.

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ANTENATAL PREDICTION OF HAEMOLYTIC DISEASE OF NEWBORN COMPARISON OF LIQUOR AMNII AND SEROLOGICAL STUDIES

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When faced with a pregnant, sensitized, rhesus-negative woman it would be advantageous to have a reliable guide to whether the maternal and foetal blood groups were in fact incompatible in this pregnancy, and if this were so an indication of the severity of the haemolytic process would assist in the management of the case. A knowledge of the past history alone is not always enough, because the baby may be rhesus-negative if the father is heterozygous, and even with a homozygous father the severity of the disease may vary from pregnancy to pregnancy.

As a criterion for assessing the severity of haemolytic disease the maternal antibody titre has been shown by some workers (Kelsall and Vos, 1952; Allen and Diamond, 1958; Tovey and Valaes, 1959; Dique and Wrench, 1959) to be correlated with the severity of the haemolytic process.

Another approach to the problem is the study of liquor amnii. Bevis (1956) showed that spectrophotometric analysis of the liquor in cases of haemolytic disease revealed an increase in blood pigments. Continuing this line of investigation, Walker (1957) has shown in a preliminary report that it is possible to predict with some degree of accuracy whether the baby will be affected or not by a study of the shape of the spectral absorption curve relative to bilirubin. The presence of oxyhaemoglobin is not important because it is only a reflection of blood in the liquor. More recently M. Mayer (personal communication, 1960), Cary (1960), and Liley (1961) have reported similar success by the use of this method.

If bilirubin could be measured more accurately in the liquor it might be possible to make a more objective prediction. It was decided, therefore, to examine the liquor in a series of cases for the presence of bilirubin, both qualitatively and quantitatively, and, in view of the results obtained by other workers, to carry out antibody titres simultaneously. From October, 1959, to October, 1961, 156 patients have been so examined; all the predictions were made on the analysis of the spectrophotometric curve. The quantitative bilirubin levels and the antibody titres were analysed retrospectively.

Material and Methods

Liquor Amnii Specimens

The technique of obtaining liquor amnii requires to be stressed, for the procedure is not a difficult one if the actual site for paracentesis is accurately determined. It will be appreciated that the foetus *in utero* is in an attitude of flexion, and with the arms and legs flexed there is a definite gap between the upper and lower