Papers and Originals**EVOLUTION OF DIRECT ARTERIAL SURGERY FOR
CLAUDICATION AND ISCHAEMIA OF LEGS****A NINE-YEAR SURVEY**

BY

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Over the last decade the evolution of direct arterial surgery has been rapid. The emphasis has shifted from the indirect operation of sympathectomy to a direct surgical attack on the blocked artery where possible. During this period the techniques available for dealing with blocked arteries have multiplied, and at present there is a bewildering choice of various types of graft for replacing or by-passing the blocked segment, as well as various techniques of thromboendarterectomy.

We have given most of these techniques a trial over the nine years, but our experience has led us now to prefer what we term the "radical rebore" type of operation for handling most arteriosclerotic blocks of the lower-limb arteries where this is possible. Sometimes, combined with this procedure, a venous autograft or homograft implanted on the by-pass principle is used.

Clinical Material

Since 1952 we have performed over 300 direct arterial operations, most of them on aorto-iliac or femoral arteries. This paper presents a detailed clinical survey of 230 of these patients who underwent operation for segmental atherosclerotic thrombosis of the aorto-iliac vessels and/or the femoral artery up to the end of 1961.

At present, out of about 150 persons per year seen as out-patients, about one-third are accepted for investigation and direct arterial surgery. Prior to 1960 only patients with very severe claudication and those with threatened loss of limb from ischaemia were considered for operation, but more recently, since the operations have become more standardized and less risky, patients with simple claudication who wanted treatment have been accepted for surgery.

Distribution of Blocks in Main Arteries

For this purpose the group of 230 patients who underwent direct surgery of the aorta, iliac, or femoral arteries for segmental arteriosclerotic block have been analysed. All these patients have been investigated by arteriography, the majority by aortography.

A consideration of the distribution of the lesions, as presented in Table I and Fig. 1, leads us to recognize certain basic and interesting aspects of the problem. There are three main points we wish to stress.

TABLE I.—*Distribution of Arterial Blocks*

Aorto-iliac	79 cases	34%
Local external iliac and/or common femoral	11 "	5%
Superficial femoral	140 "	61%

Of the 90 cases with aorto-iliac occlusion, 31 had a blocked femoral artery as well, and therefore had rest pain and severe ischaemia, and in most cases gangrene or pre-gangrene of toes.

1. The lesions we have demonstrated and operated upon range from very localized strictures and blocks in arteries which are relatively "good" to extensive blocking of long stretches of artery by consecutive thrombosis in arteries which are heavily affected by atherosclerosis. This diversity of lesions means that every patient is really an individual problem, and makes the presentation and assessment of this material by statistical methods difficult.

2. In nearly every case of claudication or severe ischaemia an aortogram is necessary, so that the state of the aorta and iliacs can be visualized as well as the femoral artery. In 31 of the 90 in the aorto-iliac group two or more blocks in the arterial tree to a limb were present. This total assessment of the whole arterial tree from aorta to popliteal and tibial arteries is necessary if long-term success with direct surgery is to be considered. When a patient has a blocked femoral artery and also a higher block or stricture in the iliacs or common femoral artery it is essential to operate on the major artery to restore or improve the total inflow into the limb from above. It is often not necessary to operate on the femoral artery at all in these cases, as great improvement is obtained by dealing with the major artery and restoring full flow into the profunda. This principle together with illustrative cases was described by us in a previous paper (Cockett and Norman, 1958) and has also been stressed by Leeds and Gilfillan (1961).

3. Attention is drawn to the relatively small group of 11 cases in the aorto-iliac group, in which a localized block existed in the external iliac and/or common femoral only. This small group is of interest and importance. Their symptoms are always relatively severe, as the main flow into both the superficial femoral and its main collateral, the profunda artery, is cut off. Thus often their symptoms are relatively bad, with severe claudication, a cold foot, and rest pain. The result of direct surgery in this little group is particularly good.

Age Distribution and Indications for Operation

About half these operations have been undertaken for the relief of really severe ischaemia, often with rest pain and the threat of amputation for gangrene of toes hanging over the patient. Where this indication has existed we have proceeded with the operation almost irrespective of age or associated cardiovascular lesions.

FIG. 1.—Distribution of arterial blocks in 230 cases.

The other half of the operations have been done for more or less disabling claudication. Here a higher standard of general fitness has been demanded, and these patients therefore have been drawn on the whole from a somewhat younger age-group.

From a consideration of Figs. 2 and 3 it will be clear that the bulk of patients considered worthy of operation were between the ages of 45 and 60—that is to say, the later working period of a man's life, when he is still active and wishes to remain so both in his work and in

FIG. 2.—Age of patients operated on. Aorto-iliac group (90 patients). FIG. 3.—Age of patients operated on. Femoral group (140 patients).

his leisure. It is interesting to note that in the femoral group 21 of the patients were under 45.

Many previous workers have stated that the only indication for operation on a patient with claudication should be when he cannot do his work. We have not felt ourselves bound by this definition. Many claudicants can do their work, which is often of a sedentary nature,

TABLE II.—Aorto-iliac Group—Arterial Homografts

1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
<div> <p>27 Cases</p> <p>2 Primary failures</p> <p>Hospital mortality 2</p> <p>ileus coronary</p> <p>Graft blocked</p> <p>Died. Graft patent</p> <p>No follow up</p> <p>Died. Causes ?</p> <p>Graft obliterated</p> <p>Died. Graft patent</p> </div>									

Analysis: Out of 23 successful cases only 2 have had late failure of the graft. 2 died soon after leaving hospital. The remaining 19 have functioned perfectly over a follow-up period of from three to eight years.

but find that they cannot enjoy their leisure as they cannot get about. If a man in the 50-60 age-group suddenly becomes immobilized by claudication, often a steady deterioration, both mental and physical, sets in. He puts on weight, takes less and less exercise, and becomes depressed or apathetic. The change in this general "rundown of life" after a successful operation for claudication is often dramatic and gratifying. They are among the most grateful patients that one can have.

Types of Operation Performed and Evolution of Present Technique

Over the nine-year period covered by this paper there has been an interesting evolution of technique.

During the first five years the emphasis was on grafts, stored arterial homografts, vein autografts, and then

TABLE III.—Aorto-iliac Group—Teflon and Dacron Grafts

	1959	1960	1961	1962
<div> <p>18 Cases</p> <p>No primary failures</p> <p>Hospital mortality 2</p> <p>pulmonary embolus</p> <p>perforated peptic ulcer</p> </div>				

Analysis: Out of 16 successful cases five blocked over a period of from three months to two years. The other 11 remained patent for follow-up periods ranging from one to three years.

various synthetic prostheses such as "teflon," and later "dacron." Direct reboring of arteries was attempted very little. However, since 1958 the whole emphasis of our technique has shifted to the direct surgery of the blocked artery, reboring it. This "rebores" or "disobliteration" or "thromboendarterectomy" of an occluded arterial segment was in fact the first type of direct arterial operation carried out in man, and the method was described originally by Dos Santos in 1947. We have used the term "rebores" for this operation because it is simple and expressive of what is actually done. It is extremely useful also in explaining the operation to patients as they understand rebores at once.

The results in these early procedures were not very good, and for a long time this type of operation was reserved for a very localized block or obstruction in an artery of large calibre. However, Wylie and Gardener (1955) remained faithful to this type of operation during the 1950's, when arterial grafts of all sorts were being done in increasing numbers. Then came the introduction of the ring arterial stripper by Cannon, Barker, and Kawakami (1958), and this greatly increased the scope and possibility of direct reboring of arteries.

In assessing the results of the various types of operations it is necessary to consider the aorto-iliac group and the femoral artery group separately. In the larger arteries of the aorto-iliac group the long-term results of all types of operation are, on the whole, satisfactory, although the mortality is higher. The surgery of the femoral artery, however, has been a much tougher problem, and only recently has a technique been evolved

TABLE IV.—Aorto-iliac Group—Rebores—(Thromboendarterectomy)

Analysis: Of 37 successful cases, only two have shown late failure. The remainder have remained patent during a follow-up period ranging from nine months to six years.

which appears to give a high initial success rate and good long-term patency.

Aorto-iliac Group: Analysis of 90 Cases

Three types of operation have been done in this group: (1) homografts; (2) prosthesis replacement, either teflon or more recently dacron; and (3) direct rebore or thromboendarterectomy.

Some of the technical considerations and operative details of the method of inserting these grafts and doing the rebores have been discussed in our previous paper (Cockett and Norman, 1958), and it is not proposed to mention this aspect of the matter further here.

The follow-up in these three groups is given in Tables II, III, and IV. Over the whole group of 90 patients the immediate mortality has been 9 (10%). This is an appreciable mortality, but these are all major abdominal operations, with the attendant risks of ileus due to a long retroperitoneal procedure. In addition, many of these patients are in an advanced age-group, and are arteriosclerotics, and so coronary thrombosis, pulmonary embolism, and mesenteric thrombosis have taken their toll in death and complications.

However, the striking thing, perhaps, on surveying these three groups of results is

FIG. 4.—Evolution of surgery of atherosclerotic thrombosis of femoral artery.

the excellence of the long-term follow-up results in the group of homografts, and rebore particularly. Among the homografts there are 12 with follow-up periods of over five years, all symptom-free, fit, and well.

The longest follow-up is in Case 2 in this group. This patient had a homograft replacement of the right external iliac and common femoral artery in April, 1953. This graft is still functioning, exactly nine years later. We have not had any case of late aneurysm formation or late rupture in this group. Nearly as impressive are the rebore with six cases patent for four years or more. The cloth grafts, using first teflon and later dacron prostheses, have not done quite so well. Some, but not all, of these poor results may be accounted for by the fact that cloth grafts were occasionally used for patients with very bad arteries indeed.

On the basis of these results we feel that aorto-iliac surgery is justified wherever symptoms such as severe claudication, rest pain, or threatened gangrene warrant it. We feel that a rebore or homograft are the two preferred types of operation, with a woven dacron graft as a very good second best. A graft is usually better when the arteries are heavily calcified. But for most cases we now prefer the radical rebore type of procedure.

Femoro-popliteal Group (140 Cases)

These constitute the bulk of the problem. The evolution of our approach to this problem can be appreciated best by referring to Table V, which shows the types of operation performed over the years. Also the series of diagrams comprising Fig. 4 graphically represent the progress in the technique of treating these lesions.

TABLE V.—Number and Types of Operation Used for Femoral Artery Occlusion Between 1952 and 1961

Type of Operation	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Total
Excision of blocked segment, end-to-end homograft replacement ..		12									12
Long by-pass graft (homograft) ..			12			2	4	9	2		29
Long by-pass graft (teflon) ..								4	8		12
Rebore (thromboendarterectomy)					3	13	11	6	21	33	87
Total ..											140

Our operative technique went through four phases:—
Phase 1 (1952–3): Resection of blocked segment, and end-to-end replacement with an arterial homograft.
Phase 2 (1953 and onwards): The long by-pass principle. Using first arterial homografts or autograft veins, then teflon or dacron crimped tubes of the Tapp-Edwards type.
Phase 3 (1956–9): The local rebore type of operation.
Phase 4 (1959–): Total femoral rebore, with or without terminal vein graft.

Phase 1

Twelve cases of superficial femoral artery thrombosis were treated by resection of the block and replacement by a stored arterial homograft (Eastcott, 1953) sewn into place by end-to-end technique. In all 12 cases the initial result was excellent, there was full restoration of pulses to the limb, and all claudication and ischaemic symptoms disappeared.

However, the follow-up of these cases was extremely disappointing. Most of them had reblocked after six

to eight months. Only one remained patent for more than one year.

Fortunately, arteriographic studies of some of these patients just before they reblocked, and the examination of several operation specimens just after the blockage, gave the clue to the long-term failure of this type of graft. Briefly, it was found that at the anastomosis between the fresh thin graft and the thick irregular host artery there was unavoidable narrowing and irregularity of flow. This irregularity of flow caused deposition of platelet thrombus just beyond the anastomosis in the parent artery and final complete occlusion. This sequence of events is shown diagrammatically in Fig. 5. Fig. 6 shows an arteriogram of such a case just before occlusion.

These results were confirmed by Linton and Menendez (1955). The failure of these cases led us to attempt the next type of operation.

Phase 2: The Long By-pass Procedure

It was now known that in many cases of superficial femoral block the arteriosclerotic changes in the artery were concentrated at the adductor canal and often became less marked as the popliteal was approached. The upward extension of the thrombosis nearly always stopped short at the origin of the profunda, leaving a large patent common femoral artery just below the inguinal ligament.

FIG. 5.—Mechanism of blocking of short end-to-end grafts of femoral artery.

FIG. 6.—Femoral arteriograms of a patient before (A) and six months after (B) insertion of a homograft by the end-to-end technique. This graft blocked off completely one month after the arteriogram was done. Picture shows very well the way in which these grafts fail by a gradual deposition of thrombus and narrowing of the artery just above and below the graft.

The long by-pass graft introduced two new principles. (1) Most of the arteriosclerotic process in the femoral artery was by-passed so that the graft would be sewn on to relatively good artery, the common femoral at the top end, and the lower part of the popliteal at the lower end. (2) The end-to-side large lumen type of anastomosis was introduced. This type of anastomosis was much more satisfactory when dealing with anastomoses between smaller arteries such as the femoral, as it allowed a greater flow with less distortion of the stream than the older end-to-end anastomoses, owing to its larger cross-sectional area. The technique and advantages of the type of anastomosis were fully described in our previous paper (Cockett and Norman, 1958) and by other authors (Linton and Menendez, 1955).

The first cases of this type had been done by Kunlin (1949, 1951) using vein autografts, and soon after a meeting in Paris one of us (F.B.C.) used a long stored arterial homograft in this way in September, 1953. During 1954-5, 12 of these long by-passes using arterial homografts were done. Then we continued to use this principle in a small number of selected cases up to 1960, employing either arterial homografts or vein homografts, or vein autografts. The results are shown in Table VI.

The analysis of these cases shows results which are much more satisfactory than the old end-to-end type of graft. In fact, 50% of the cases remained patent for more than two years, and eight of these cases were still patent at the time of writing.

In about half the cases the graft has saved a limb which would otherwise have needed amputation; the other half were severe claudicants. Judged against this background, these results are fairly worth while, but not by any means satisfactory, and we felt that we should be able to do better.

There are many inherent difficulties in the performance of a long by-pass graft. The major difficulty is in getting a steady supply of grafts which are both long enough and big enough. Long autogenous vein grafts are often of too narrow a lumen to get satisfactory anastomoses and to conduct a really large fast flow. Often we have found that the length of graft available was the governing factor in deciding where the

anastomoses should be, a handicap which vitiates the expectation of a good long-term result.

In 1959 and 1960 we did 12 long femoral by-pass operations, using the flexible Tapp-Edwards teflon prostheses. The results (Table VII) speak for themselves, and were if anything rather worse than those achieved by the original short end-to-end grafts. Moreover, another factor is of importance here—namely, that after the failure of a long teflon graft the final state of the limb is usually much worse than it was before. This is because a further stretch of the distal femoral artery beyond the original block is inevitably blocked off when the graft attached to it thromboses. (This has been confirmed at operation several times.) Most of these patients with graft failures have had to have their legs amputated. These results have been confirmed by Edwards (1960), and the failures have been very competently discussed and reviewed by Shaw (1962).

We have therefore not performed any more long by-passes using cloth grafts in this way, and we feel that, in general, cloth grafts are unsuitable for such use below the inguinal ligament, except in certain rare, exceptional circumstances—that is, when the femoral artery is large and dilated and only a short gap has to be bridged, as sometimes after an aneurysm excision. These general conclusions have also been confirmed by Linton and Darling (1962).

Phases 3 and 4

During 1956-9 we had been doing a steady small number of cases of direct rebore of the local blocked segment in the femoral artery (see Table VIII). The technique was usually that of several small arteriotomies, and stripping out of the blocked segment either by direct dissection, or by using some home-made ring strippers of the type described by Cannon *et al.* (1958). However, usually the operation was fairly limited to clearing the actual segment of the artery which was blocked. General heparinization of the patient was not undertaken until just before the clamps were taken off and the blood was allowed to flow. Heparinization lasted about four hours after release of the clamps.

TABLE VII.—Long Teflon By-pass Grafts

1959	1960	1961	1962
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→
→	→	→	→

Analysis: 12 operations: 2 primary failures; no deaths. Of the remaining 10, 8 have blocked in a follow-up period between 2 months and 14 months. Only two grafts have remained patent for over two years. (These were in the right and left leg of the same man, who had an exceptionally large dilated femoral artery beyond the blocks.)

TABLE VI.—Long By-pass Tissue Grafts

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
① Arterial Homografts	→	→	→	→	→	→	→	→	→	→
2 Primary failures										
2 deaths										
② Vein Autografts										
2 Primary failures										
No deaths										
③ Vein Homografts										
No Primary failures										
1 death										

Analysis: 29 cases done. 3 Patients died (1 sepsis, 1 coronary thrombosis, 1 pulmonary embolus). 4 Primary failures, mostly due to technical reasons. Of the remaining 22 cases, 11 remained patent for two years or more; four grafts have remained patent for four years or more.

follow-up results showed that they were doing rather well. There were seven primary failures, mostly due to inexperience and errors of technique. But of the 26 cases in which flow was re-established 16 were patent and had a satisfactory result at the end of 1959. Moreover, in most of the ones which failed the leg was not strikingly worse off than it was before the operation (in sharp contrast to the failed teflon grafts). From Table VIII it will be seen that further follow-up of those 16 cases which were patent at the end of 1959 showed that 14 out of the 16 were still patent in 1962 and had been patent for from two and a half to five years.

These results were better than the other types of surgery of the femoral artery. The mortality and

TABLE VIII.—*Femoral Rebore Operations (1956–1961) (87 Cases)*

1956	1957	1958	1959	1960	1961	1962
<div> </div>						
<div> <p>7 Primary failures No deaths</p> <p>Newer and better technique introduced in 1960</p> <p>7 Primary failures No deaths</p> </div>						

Analysis: Up to end of 1959: 33 cases. No deaths. 7 Primary failures. Out of 26 successful cases, 14 are still functioning (2½ to 5½ years), 18 functioned for two years or more. Since 1959 (new technique): 54 cases. No deaths. 7 Primary failures. Out of 47 successful cases, 46 are still functioning (follow-up period 10 months to 2½ years). 1 Case blocked after 1 year (after an arteriogram). 1 Case blocked at 1½ years, was rebored again, and is still functioning. 1 Case blocked with an embolus at 1 year, successful embolectomy.

complication rate was lower, and the long-term patency was better. This encouraged us to study the technique and possibilities of this type of operation more fully. As a result, at the end of 1959 a new and much improved technique and conception of the operation was introduced.

Technique of Total Femoral Rebore (see Figs. 4 and 7)

The new factor in the concept of the operation has been that the *whole* femoral artery, from the origin of the profunda to the bifurcation of the popliteal, has been stripped free of atheroma in most cases. This was done through several small arteriotomies, using the Cannon arterial strippers. Thus the whole stretch of artery, quite irrespective of the original site or length of the block, is stripped. This ensures that an even, smooth, and large channel is obtained right down to the lower part of the popliteal, without projection or

sudden narrowings in the lumen—factors which we know contribute to late occlusion.

The other new factor in the technique of the operation has been the fuller use of heparin. The patient is placed on his side with the limb to be operated on below, and the other limb held out of the way by a sling. The whole of the femoral artery from the common femoral down to the adductor canal is exposed and isolated through one incision. The popliteal artery down to its bifurcation is exposed by a second incision in the popliteal fossa. As soon as this dissection is completed the patient is given 9,000–10,000 international units of heparin (according to size and weight) intravenously. Then the intra-arterial part of the operation is started and completed under full heparinization. The effect of the heparin takes about four hours to wear off, and so the blood coagulation is inhibited for two to three hours after the end of the operation. Thus the first two to three hours of blood flow through the long rebored segment is “protected,” as it were, by general heparinization.

During this two to three hours of post-operative heparinization there is a steady ooze of blood from the wounds, which are only loosely approximated, into the dressings. During this early post-operative period the patient may need from 1 to 3 or 4 pints (570 ml. to 1.7 l. or 2.3 l.) of blood to maintain his blood-pressure.

We have found two factors—protection of the flow through the newly rebored segment by heparin for two to three hours, and maintenance of blood-pressure during and in the early hours after operation—of vital importance in the technical success of this type of operation.

About 24 hours after the main operation delayed primary suture of the wound is carried out as originally recommended by Rob, Eastcott, and Owen (1956). At this second operation clots are cleared from the wound, and it is confirmed that the rebored segment is pulsating. On three occasions pulsation of the segment was found

FIG. 7.—Right: total rebore. Left: local rebore. The difference between a local rebore and a total rebore. This patient had a local rebore of the blocked segment done on the left side in 1959. Then in 1960 he had a total femoral rebore from profunda origin to low popliteal on right side. Note that several branches from the rebored segment are functioning.

to be absent at the delayed primary suture, and further obstructing lesions in the artery were cleared, turning a potential failure into a success.

There is one further important technical point in the operation, and this is the correct assessment of the degree of involvement of the lower part of the popliteal artery. A popliteal artery which is a little thickened with atheroma on one side only is favourable, and one can usually end the rebore successfully in this type of case low down in the popliteal artery. However, when the popliteal artery is uniformly thickened all round its diameter right down to its bifurcation it is difficult to end the rebore in this type of artery without internal flap formation. In such cases it is better to rebore down to the adductor canal, and then finish with a short by-pass type vein graft (either autograft or homograft) (see Fig. 4). Only short segments of vein (6–8 in.; 15–20 cm.) are necessary for such grafts, and therefore it is much easier to pick a segment of vein of good size, capable of transmitting a good flow.

Results

The results of this type of operation are shown in Table VIII from the beginning of 1960 onwards. Of the 54 cases done during 1960 and 1961, seven were primary failures, almost all due to the fact that the popliteal was obliterated down to its bifurcation and beyond, so no adequate peripheral segment could be found to rebore into or graft on to.

Of the 47 cases which were completed, five were of a local nature on the profunda and common femoral arteries, leaving 42 cases of full-length rebore for analysis. Of these 42 cases, all but one were patent at the time of writing; 11 have remained patent for two years or more, and 25 have remained patent for one to two years. The remainder have not yet completed a year and so are not significant from the point of view of a follow-up study. The mortality in the whole group of femoral rebore was nil. In only one case did failure of the rebore lead to loss of a limb, which might not otherwise have required amputation. This last remark is a great point in favour of this operation, because relatively rarely does a failure, either primary or secondary, leave the limb appreciably worse off than it was in the first instance.

Conclusions

This nine-year survey of arterial surgery brings interesting light on many of the problems associated with the surgery of peripheral arteriosclerosis. We have learned many lessons in the techniques of this type of surgery over the period under review, but this is not the place to present these. We think that there are three major conclusions which have come out of all this work.

1. Place of Surgery in Arteriosclerosis

It has been stated that once a patient develops intermittent claudication or ischaemic peripheral symptoms the prognosis for life is so poor that most of them succumb to coronary disease or cerebrovascular accident within three to five years. Thus it is argued that it is simply not worth while operating on these patients if their expectation of life is so short.

Our follow-up studies have not confirmed this. In fact, a study of the various follow-up tables presented in this paper shows that in this particular group of cases—namely, patients in the 50–60 age-group who develop

claudication—the expectation of life is surprisingly good. For instance, in the whole group of femoral artery occlusions (140 cases) there were only eight deaths from all causes in the whole nine-year period under review. In the aorto-iliac group of 90 cases 10 died during the period under review from associated arteriosclerotic conditions (mainly coronary thrombosis and mesenteric thrombosis).

In fact, it is our experience that the average man in the 50–60 age-group who develops claudication without at the same time having evidence of coronary ischaemia has a very good life expectancy and is a good surgical risk.

2. Surgery of Occluded Femoral Artery

In the 140 cases of femoral artery occlusion the overall operative mortality was 2%. The femoral artery occlusion or adductor canal lesion, occurring by itself in patients in the 45–65 age-group, is often a relatively isolated arteriosclerotic lesion, the patient being otherwise fit and having a nearly normal life expectancy for his age. The treatment of this lesion by surgery would therefore be highly desirable if a simple, safe method could be evolved which gave a reasonable long-term patency. This has proved a “tough proposition.” It has been shown that neither end-to-end grafts nor synthetic cloth grafts inserted on the by-pass principle come anywhere near achieving these criteria of a satisfactory operation. Long by-pass arterial homografts or venous autografts have come slightly nearer to the desired criteria. However, in our hands the operation which has most nearly fulfilled these desired criteria is the total femoral rebore operation, with or without terminal short vein by-pass graft (see also Linton and Darling, 1962).

Over our whole series of 87 cases of direct rebore there has been no death. Since introducing our new and improved technique of total femoral rebore in early 1959 we have done 54 cases with a primary success rate of 88%. Of the 47 cases successfully operated on up to the end of 1961, 46 are still functioning (over a follow-up period of one to two and a half years).

Thus we feel that this type of operation most nearly reaches the desired standard of safety, simplicity, and a good long-term result.

3. Surgery of Aorto-iliac Disease

Operations on the aorta and iliac arteries necessitate a major abdominal exposure, are long and intricate operations, and therefore fall into a different category from operations on the femoral artery. Also patients with aorto-iliac disease have a definitely increased incidence of associated arteriosclerotic lesions (coronaries, mesenterics, carotids, and other limb arteries). Thus operations on patients with aorto-iliac disease are major operations and the mortality rate and complication rate are higher. In our series of 90 cases the mortality rate was 10%.

On the other hand, most of the patients have been very severely handicapped. In fully one-third of the cases severe rest pain and threatened loss of one or both limbs has been the indication for operation.

In the 90% who have survived operation the results achieved have often been spectacular and the follow-up results excellent. On studying Tables II, III, and IV it will be seen that some remarkable long-term successes have been achieved. The longest recorded success is the homograft which was inserted in the external iliac artery

in 1953 and is still functioning—a follow-up of nine years. Also in the homograft group there are 10 patients whose major homografts have been functioning successfully for six years or more. Of the three types of procedure used the stored arterial homografts and the rebore types of operation have given the best results. The group of cloth grafts (18 cases, Table III) have also given acceptable results, but with a higher incidence of late occlusion than the others. At the present moment, therefore, when dealing with aorto-iliac disease we prefer a rebore type of operation, with use of either a homograft or cloth graft on certain cases which for technical reasons are unsuitable for rebore.

Summary

A survey of the long-term results in 230 patients with peripheral ischaemia and claudication treated by direct arterial surgery is presented.

There were 90 cases of aorto-iliac occlusion, with an overall mortality of 10%. The best long-term results here were achieved by homograft replacement or by total rebore of the aortic bifurcation and a variable length of the common and external iliac arteries. The results of cloth grafts were not quite so good in our hands.

There were 140 cases of femoral artery occlusion. When this occurs alone in the 50–60 age-group it carries a good life expectancy.

The results of end-to-end homografts, by-pass homografts and vein grafts, crimped cloth (teflon and dacron) grafts, and thromboendarterectomy or “rebore” operation are reported and the follow-up results compared.

End-to-end grafts and cloth grafts are the worst, and are considered as not worth doing below the inguinal ligament in our experience.

Long by-pass tissue grafts (preferably homograft or autograft vein) give much better results.

However, the best long-term results of all are given by the recently evolved “total rebore” operation on the femoral artery, sometimes with terminal vein graft. Eight-seven cases operated on without mortality are reported, 54 of which were total rebores.

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EARLY RESULTS IN 95 PATIENTS UNDERGOING FEMORO-POPLITEAL BY-PASS GRAFT

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Angioplastic techniques are now well established in the treatment of occlusive disease of the vessels of the trunk and limbs. Although the use of endarterectomy and porous grafts is highly successful in the aorta and common iliac arteries, similar procedures in the smaller vessels below the inguinal ligament have given less gratifying results. Obstructions in the leg treated by endarterectomy alone, or graft replacement with end-to-end anastomosis, were often followed by a prohibitive incidence of early thrombosis (Linton, 1955). Kunlin (1951) suggested a by-pass graft with end-to-side anastomosis to the host vessels because of the wider anastomosis that could be made with these smaller vessels and the smaller disturbance of the established collateral vessels. This technique was soon found to have fewer failures than the excision of the obstructed segment with end-to-end anastomosis (Linton, 1955; Crawford *et al.*, 1955). Since then many reports on this operation have confirmed the original findings (Morris *et al.*, 1959; Whitman *et al.*, 1960; Roberts and Hardesty, 1961). In spite of the improved results it became clear at the very outset that the successful insertion of a femoro-popliteal by-pass graft was followed by a higher incidence of late graft thrombosis than in the larger and more proximal vessels (Shaw and Wheelock, 1955), and the reasons for this have been under study during recent years (Edwards, 1960). Meanwhile with the increasing study of the results of these operations certain facts have emerged which have clarified and narrowed the selection of patients for this procedure. In this report many of these points are discussed.

Clinical Material

This paper is based on the study of 95 patients (7 females, 88 males) who underwent a total of 106 femoro-popliteal by-pass procedures. All these patients suffered from atherosclerosis and had thrombosis or stenosis of the superficial femoral artery. The mean age-group of the patients was 64 years. The incidence of related disease has been assessed with regard to those conditions that are known to be associated with peripheral atherosclerosis. Three patients suffered from diabetes, a surprisingly low incidence of this disease. Six of the 95 patients had a previous history of myocardial infarction or E.C.G. changes of myocardial ischaemia. No patient, however, was suffering from angina at the time of operation. Twenty-six patients (27.5%) had a diastolic pressure greater than 95 mm. Hg. Only one

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