

## DIRECT ARTERIAL SURGERY

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Since the last publication on arterial surgery from this department,<sup>1</sup> we have had the opportunity of dealing with many more cases, and our total from January 1957 to the end of 1959 has been brought up to 180. This added experience has enabled us to assess the relative merits of the various procedures in our hands, and has helped to clarify the indications for direct procedures on the vessels. In addition one of us (J.H.L.) has had the opportunity recently of visiting vascular clinics in the USA and in England, and this has been of extremely great value to us in the handling of these patients. It is the purpose of this paper to outline briefly our present views on certain aspects of the subject and, in particular, chronic occlusive disease as it affects the lower limbs.

We have now used direct arterial surgery on aneurysms, both peripheral and abdominal, arteriovenous fistulae, and occlusive arterial disease of the lower aorta, iliac and femoral vessels, and carotid arteries. The results of direct surgery on the arteries are often dramatic, and quite out of proportion to what could be obtained by the methods previously at our disposal. Pulses which were absent reappear, rest pain disappears, and incapacitating claudication not only improves but vanishes completely. This, however, is not the rule, and not every patient suffering from arterial disease can be benefited by surgery. Many patients still have to persevere with conservative measures, a few are benefited by sympathectomy, but a considerable number are suitable subjects for direct surgical procedures of one kind or another. In any particular case, therefore, the problem always arises whether surgical measures are indicated and, if they are, which methods are most likely to give the best results, both immediate and late.

Fine judgment and careful assessment play a most important part in the management of these patients, not only pre-operatively but also at the time of the operation and in the post-operative period. Poor judgment may lead to a catastrophic result—the unnecessary loss of a limb or even of a life. Patients who require this type of surgery suffer from atherosclerosis, and all too often the symptoms from which they seek relief are merely a localized manifestation of a widespread disorder. Up to the present time it has been the policy in this school to have the direct arterial surgery performed by a limited number of surgeons until the various techniques have been completely mastered.

*Aortography* is today a commonplace procedure. All cases of occlusive arterial disease coming to surgery are investigated pre-operatively by means of arteriography. Both the translumbar and the percutaneous femoral route (Seldinger) are employed, depending on the particular

requirements, and up to the end of 1959 well over 200 aortograms were done in our department. Although aortography was employed originally for abdominal aneurysms, we have now discarded it because we feel that for this condition the procedure is unnecessary, does not provide accurate information and, most important of all, is liable to produce serious complications. For obliterative arterial disease affecting the lower limbs we have found aortography extremely helpful, and we have been fortunate in not having had a single serious complication following the procedure in our first 200 cases. Nevertheless, we are fully aware of the dangers of aortography, and we recommend it only in those cases where we feel useful information may be obtained in a patient who might be benefited by surgery.



Fig. 1. Extensive atheromatous disease of lower aorta and iliac arteries with complete occlusion of internal iliac. Note the gross narrowing at origin of common iliacs.

We do not make this method a routine in the investigation of all our cases of peripheral vascular disease.

A great deal has been learnt from these arteriographic studies; indeed, much of our present concept of obliterative arterial disease is based on knowledge obtained from radiographic investigations. The following are a few observations that may be of interest:

#### Sites of Occlusion

1. There is an extraordinary tendency for incomplete or complete occlusions in the large arteries to occur at certain situations. Thus it is common at the sites of bifurcation of the aorta and the iliac vessels, and at those sites where large vessels pass beneath ligaments, especially if these are situated at the flexures. The aortic bifurcation is a very common site for stenosis or occlusion; in fact this portion of the aorta, from the level of origin of the renal arteries down to its bifurcation, is particularly prone to the deposition of atheromatous material. In our series, the commonest site for occlusion to commence was in the superficial femoral artery at the level of the adductor hiatus.



Fig. 2. Complete occlusion of left common iliac artery and marked stenosis at origin of right common iliac. Note the extensive disease in the lower aorta.

2. Not uncommonly, one finds a remarkably localized occlusion confined to a short segment in a large artery, while the remainder of the arterial tree appears to be normal. The commonest of these situations is at the aortic bifurcation, at the bifurcation of the common iliac arteries, in the common femoral artery just beneath the inguinal ligament, and in the superficial femoral artery at the adductor hiatus.

3. Very commonly, a comparatively localized superficial femoral block is accompanied by a similar lesion in the more proximal large vessels.

4. The commonest finding of all is that there is extensive atherosclerotic disease in all the large arteries in this region and that the stenotic areas are merely localized exaggerations of the atherosclerotic process.

5. Although the aortogram provides extremely useful information, it is inadequate in two main respects:

(a) It usually does not indicate the full extent of the disease; almost invariably one finds at operation that the atherosclerotic change is more extensive than was suggested by the radiographs.

(b) Information regarding "run-off" may be misleading. The fact that an artery is well outlined by dye on an arteriogram does not necessarily mean that the flow of blood in that vessel is normal. In fact, a slow stream of dye in a vessel is likely to give better contrast than a rapid stream. Narrowing of a large proximal vessel, no matter how limited its extent along the vessel, will slow down the distal stream where the vessels are relatively normal in calibre, and here the arteriogram may suggest that the arterial tree is normal.

#### Clinical Aspects

Before symptoms of vascular insufficiency in a limb become apparent, the main vessel to that limb must be narrowed down very considerably at a proximal level; it has been stated<sup>2</sup> that in general symptoms of insufficiency do not occur until the lumen above has been reduced to about 70% of normal.

In most cases intermittent claudication is the earliest symptom of obliterative atherosclerotic disease in the lower limb. This is described as a cramp-like pain, but not infrequently the patient merely complains of a feeling of tiredness or lameness in the limb. These symptoms, whether pain or a feeling of tiredness, are always quite characteristic in that they always appear only after exercise, that they begin only after a certain amount of exercise, that this amount of exercise is always constant for each patient at a given time, and that they disappear rapidly on resting. Pain in the limbs which comes on at the onset of walking, or which does not disappear within a few minutes of resting, is almost certainly not intermittent claudication. Pain which is still present after 10 minutes of resting is not intermittent claudication.

The situation of the claudication pain is usually a fairly reliable guide to the level of the arterial narrowing or obstruction. In this connection, it is important to remember that many cases of intermittent claudication do not have a complete occlusion proximally and that, because the vessel is merely narrowed, there will be palpable pulses distally. The presence of a pulse merely indicates that blood is flowing through the vessel, but it is no indication of the volume of blood passing through.

Occlusion of the superficial femoral artery gives rise to claudication in the calf. If the origin of the profunda femoris is blocked, the pain will be felt along the medial side of the thigh. When the occlusion is at a more proximal level, in the iliac vessels or in the lower aorta, the intermittent claudication extends up the thigh, and when the internal iliac arteries are occluded, there is usually severe claudication in the buttocks as well.

Narrowing of a main artery by atheroma is, to begin with, a slowly progressive process, during which time collateral vessels develop to share more and more in the arterial supply of the limb, and this process may continue insidiously until there is complete occlusion of the main artery and complete substitution of arterial supply through the collateral vessels, and yet there may be a total absence of subjective evidence when this complete occlusion finally occurs. On the other hand, narrowing often proceeds up to a point, and then superadded thrombosis completes the occlusion. In this case there are always signs and symptoms of an acute ischaemic episode.

An occlusion in the superficial femoral artery may or may not be accompanied by ischaemic changes in the leg. If these are absent or minimal, it may be assumed that the popliteal artery is patent and is being fed by collaterals bypassing the occluded segment. When the ischaemic changes are marked, it is unlikely that the popliteal artery will be patent, and in such cases the run-off at the popliteal will usually be insufficient to allow the successful attachment of a graft. In the presence of gangrene of one or more digits, it can almost certainly be accepted that the popliteal artery is completely occluded and unsuitable for a bypass procedure. The collateral circulation will have failed, and this includes the anastomosis around the knee joint.

Localized stenosis at the aortic bifurcation may proceed to a considerable degree before symptoms of vascular insufficiency become manifest and, when they do develop, they consist mainly of tiredness of the whole limb on walking.

As the condition progresses, fatigability increases to a marked degree and involves the whole leg, including the buttocks. In about 25% of these cases there is an associated impotence due to inability to maintain an erection. This constitutes the so-called Leriche syndrome.<sup>3</sup> In this connection, it is interesting to note that not infrequently impotence may be the first presenting symptom of stenosis at the aortic bifurcation, and for this reason the patient may consult his urologist in the first place.

Stenosis or occlusion of the aortic bifurcation presents as a rule with minimal ischaemic changes in the legs, and in fact it is a characteristic finding in this condition that the legs look remarkably normal. This observation, together with the fact that the pulses at the ankle are often palpable, may fool the unwary clinician into believing that the patient's symptoms are not of vascular origin. Palpation at the groin, however, will always reveal a much reduced or even completely absent femoral pulse with a bruit on auscultation. Many of these cases have been missed in the past, and are still being missed today, and their symptoms are ascribed to a variety of different conditions. We have actually had such patients referred to us after major orthopaedic operations had failed to cure their symptoms. This means that though the dorsalis pedis or posterior tibial pulse can be felt, it does not follow that the circulation in the leg is normal.

#### MANAGEMENT

##### *The Acute Occlusion*

Acute intraluminal occlusion of an artery may be due either to the sudden lodgment of an embolus, or to thrombosis in a vessel previously narrowed by atherosclerosis. These are two totally different clinical entities. The clinical picture is different, the prognosis is different and, we consider, the management is different.

Embolitic occlusion of a reasonably normal artery produces a dramatic picture of severe ischaemia. This condition carries with it a grave prognosis as regards the life of the limb, and it requires urgent direct surgical measures for its successful treatment. On the other hand, thrombotic occlusion—and this is a very much commoner event—as a rule carries with it a much better prognosis. Here the resulting ischaemia is dependent to a large extent on the degree of narrowing which was present at the time of the thrombosis, and in many instances the collateral vessels will have developed sufficiently to maintain the nutrition of the limb. It has been our experience that direct arterial surgery in these thrombotic cases, even in relatively early ones, has been most disappointing. It certainly does not achieve the dramatic results that can be obtained with embolectomy.

In our opinion it is important to differentiate between these two conditions. Statements are made that disobliteration can be performed as long as several weeks after an acute occlusion, and it is quite clear that such statements must refer to embolism and not thrombosis. Thrombosis produces an acute inflammatory reaction in and around the vessel, so that direct surgery in the form of endarterectomy becomes technically an impossible feat at this stage. At a later stage, when the acute inflammatory process has subsided, disobliteration may be a feasible proposition.

Unless the patient can be operated upon within a few



Fig. 3. Complete occlusion of both common and external iliac arteries. At operation it was possible to bypass this block and re-establish the circulation to the legs.

hours of onset, we consider it wiser in most cases of thrombosis to institute conservative treatment at the outset, and our policy now is, briefly, as follows:

- (i) Raise the head of the bed.
- (ii) Begin anticoagulant treatment immediately both by the intravenous and oral routes.
- (iii) Give special care to all pressure points—the leg to rest on a thick sponge-rubber cushion.
- (iv) Avoid heat and avoid excessive cold to the limb.
- (v) Avoid vasodilator drugs, and avoid sympathetic blocks and sympathectomy. These have no place in the treatment of the acutely ischaemic limb, and may in fact do harm.
- (vi) Associated conditions such as polycythaemia, old rheumatic heart disease, myocardial infarction, and diabetes, must of course be treated appropriately.

Within a day or two it will become obvious whether the patient is going to lose his limb or not, and in fact this is often fairly obvious at the outset.

If the ischaemic changes become more severe, an above-knee amputation is done.

If the limb survives, improvement is likely to continue over the next few weeks, and possibly months. As soon as it is evident that improvement is being maintained, the patient is made ambulant. Early ambulation is an important part of the treatment, and we are quite convinced that judicious exercise is the best stimulus for the development of collateral vessels. It is important to stress that the patient must not walk so far or so fast that he develops intermittent claudication, but that he stops temporarily just short of this. We have found that Buerger's exercises are of definite value during this period. In addition the patient is put on a fat-free diet, and is asked to continue with his anticoagulant treatment for an indefinite period, providing facilities for its scientific control are available.

On this regime many patients improve quite remarkably, and if the claudication continues to improve we advise no further treatment. In cases where after a period of some months no further improvement occurs, and where the intermittent claudication remains incapacitating, or where rest pain becomes a feature, the question of operative treatment must be assessed. At this stage it may be possible to disobliterate the occluded vessel, or perhaps to bypass the occluded segment. Where neither of these procedures is possible by virtue of inadequate 'run-in' or 'run-off', a suitably planned sympathectomy may well succeed in relieving ischaemic symptoms and improving the skin circulation sufficiently to delay amputation. It is our experience that a sympathectomy performed some months after an acute occlusion is of far greater ultimate value than one done at the time of the acute episode.

#### Chronic Occlusions

During the period under review direct surgical procedures were used on 38 cases of occlusion in the aorto-iliac arteries, and 62 in the superficial femoral (Table I).

For a long time we have been aware of the occlusions affecting the superficial femoral artery, but it is only recently that we have fully appreciated the significance of a coincident proximal stenosis. Such an event is much commoner than was formerly recognized, and no doubt in large measure determines the success or failure of a reconstructive operation designed to relieve an occlusion in the femoral artery. All

TABLE I. DIRECT ARTERIAL SURGERY: 3 YEARS 1957-59

<i>Aneurysms</i>				
Aortic ..	..	..	..	26
Iliac ..	..	..	..	5
Peripheral ..	..	..	..	21
Total ..	..	..	..	<u>52</u>
<i>Arteriovenous Fistulae</i> .. .. . 10				
<i>Acute Occlusions</i> .. .. . 10				
<i>Chronic Obliterative Disease</i>				
Aorto-iliac ..	..	..	..	38
Femoropopliteal ..	..	..	..	62
Carotid ..	..	..	..	8
Total ..	..	..	..	<u>108</u>
Total .. .. . 180				

too frequently, the proximal involvement is only partial, and the clinical picture is completely dominated by the more distal block in the superficial femoral. In such cases any attempt at reconstruction in the thigh, whether by endarterectomy or a grafting procedure, is unlikely to succeed from the outset, unless the proximal stenosis is dealt with first.

It is an elementary rule that for any kind of reconstructive procedure to be successful, or even to have a chance of being successful, an adequate run-in above and an adequate run-off below are essential. Surgeons tend to ascribe their bypass failures to a variety of causes and, although there are many good reasons why a grafting procedure may not be successful, one of the most important ones is this basic fact concerning the run-in and run-off. In many cases of superficial femoral occlusion accompanied by a diminished flow in the proximal large vessels, we have found that disobliteration in the proximal vessels alone may improve the distal circulation very considerably, merely by providing a bigger head of pressure. In most cases, of course, this is not sufficient, and the distal occlusion is dealt with, either at the same operation or at a later stage.

#### DIRECT ARTERIAL SURGERY

##### Indications

Many of the patients referred to us are beyond the scope of surgery. It is our experience that once there is gangrene of a digit, or infection of any kind in the distal part of the limb, direct arterial surgery is unlikely to succeed. This applies especially to grafting procedures. Sepsis and grafting materials are quite incompatible. Severe ischaemia in the foot, especially when there is marked rubor which does not fade on elevation of the limb, or actual gangrene of a digit, usually denotes a poor run-off at the popliteal artery and, in fact, thrombosis in the distal arterioles as well. These are usually unsuitable cases for direct surgery on the larger vessels. Attempts to endarterectomize the partially occluded popliteal artery in such cases always fail to produce a better run-off or back-flow.

In the main we have tended to reserve the reconstructive operations for patients presenting with severe claudication and those presenting with early ischaemic changes, and this applies in particular to the superficial femoral occlu-

sions, where the standard procedure up to the present time has been a bypass graft. In the proximal large vessels the picture is rather different. Here it is often possible to endarterectomize a localized segment of artery, and we are of the opinion that in such cases it should be done at an early stage, even if claudication is not severe. With improvement in technique of endarterectomy of the smaller arteries, we consider that this operation should now be advised at a much earlier stage than was our former practice. Endarterectomy of a short segment of artery is a procedure which is usually followed by excellent return of circulation and, according to reports available so far, the long-term patency is extremely good. Once the obliterative process has progressed to involve a long segment of artery, and especially if this is the superficial femoral, not only is endarterectomy a more difficult procedure, but it may well be impossible, so that a grafting procedure then has to be resorted to.

## METHODS

*Femoropopliteal Block*

The common site for commencement of occlusion in the superficial femoral artery is at the level of the adductor hiatus in the lower third of the thigh. The occlusion may be localized to a very short segment at first, and then sooner or later extends upwards and downwards to a varying degree. Commonly the arteriogram will show a similar occlusion, or else a narrowed segment not yet occluded, in the superficial femoral artery of the other limb, and situated at exactly the same level.

Early in our series 5 patients were subjected to endarterectomy, but these were all uniformly unsuccessful because the involved segment of artery was too extensive in all of them. A bypass graft was then substituted in these. In another 10 cases, exploration of the femoral and popliteal arteries showed these vessels to be unsuitable for a direct procedure. In the 47 cases, a bypass procedure was carried out (Table II). Arterial homografts were used in the first case (early in 1957) and, of these 4, the arteries are still patent in 2, in 1 the patient died of coronary thrombosis about a year after the graft operation, and in the 4th the artery became occluded. Mainly because it was difficult to obtain suitable homografts, the synthetic materials were used early on, and the prostheses used at various stages were nylon, dacron, knitted teflon and, in the last 19 cases, woven teflon.

TABLE II. PROCEDURES FOR CHRONIC OBLITERATIVE DISEASE

<i>Thrombendarterectomy</i>					
Aorto-iliac	..	..	..	..	33
Femoropopliteal	..	..	..	..	5
Carotid	..	..	..	..	7
Total	..	..	..	..	45
<i>Grafts</i>					
Aorto-iliac	..	..	..	..	4
Femoropopliteal	..	..	..	..	47
Total	..	..	..	..	51
<i>Exploration only</i>					
Aorto-iliac	..	..	..	..	1
Femoropopliteal	..	..	..	..	10
Carotid	..	..	..	..	1
Total	..	..	..	..	12

It is our experience, in common with that of most other workers in this field, that, of all the artificial materials so far devised, woven teflon grafts have given the best results in bypass procedures in the leg.

According to the many reports which are now appearing in the literature,<sup>2,4-6</sup> it would appear that, of all the grafting materials, the autogenous vein graft is superior to any other, and is more likely to give a long-term patency than any other. Unfortunately it is not always possible to obtain a suitable length of vein to provide an adequate reconstruction in every patient who may need one.

The arterial homograft, which looked promising at first has now been found wanting in several respects and is considered to be the least satisfactory of all the prostheses used so far. It is particularly liable to early degeneration, to calcification, and to aneurysmal dilatation.<sup>7,2</sup> In addition the long-term patency is disappointing.

Of the artificial grafts, a very considerable proportion, varying from about 10% to as many as 50% according to different authors, can be expected to thrombose in 6 months.<sup>8-10</sup> The Mayo Clinic in a very recent report,<sup>7</sup> has claimed a high percentage of patency after 6 months.

Reports of large series are now beginning to appear in the literature, but at the present time it is still impossible to say what the 5-year patency rate is likely to be. It is true that the long-term patency of artificial grafts is steadily improving, and there are numbers of reports where a considerable percentage of these are functioning after a period of 6 years and more.<sup>5-8</sup>

In our own series of graft operations for femoropopliteal block, although still very early, we have had 4 post-operative deaths and 10 early failures, and there have been 2 late closures (Table III).

TABLE III. RESULTS IN CHRONIC OBLITERATIVE DISEASE

Site	Procedure	Number	Deaths	Early Failures	Late Closures
Aorto-iliac	Graft	4	1	—	—
	Endarterectomy	33	—	4	—
Femoropopliteal	Graft	47	4	10	2
	Endarterectomy	5	—	3	—
Total		89	5	17	2

We are of the opinion now, that for a short occlusion in the superficial femoral artery, endarterectomy should be attempted. Where the occluded segment is extensive, and particularly when associated with calcification in the vessel, a bypass procedure is the treatment of choice. Where possible, the graft should be an autogenous vein and, when this is not available, woven teflon should be used.

*Aorto-iliac Occlusion*

Here the position is different, and we have been very impressed by the excellent results following thrombendarterectomy in many of our cases, and especially in those where a localized segment of common iliac or lower aorta was involved.

Where the lower aorta, common iliac and external iliac arteries are extensively involved, and especially when these vessels have become tortuous, narrowed and calcified, we are faced by a more difficult problem. Often in these cases there is also extensive disease in the superficial femoral and common femoral arteries, so that direct surgery becomes a heroic and unrewarding procedure. However, if it can

be shown that the common femoral artery is patent and is capable of a reasonable back-flow, then there are alternative methods available for restoration of the blood flow. Whenever possible, thrombendarterectomy is the procedure of choice, and it is the one most likely to give a good long-term result. It is estimated that this procedure is possible in only about 75% of cases where it would have been possible to bypass the obstruction by means of a graft.<sup>4</sup>

In this situation, the grafts are on the whole more successful than they are in the thigh, although the same disappointing results are obtained from homografts. It may be possible to excise a segment of artery and replace it by means of synthetic material but, in general, the method of choice is to attach the graft, either to the aorta or to the common iliac artery above, and then to the common femoral below. In some cases, where there is extensive disease in the superficial femoral artery in addition, the graft may be brought right down and attached to the popliteal artery.

Where the common iliac and external iliac arteries are extensively involved and not suitable for endarterectomy, we prefer to transect the common iliac near the aorta, endarterectomize the proximal portion into the aorta, and then attach the graft end-to-end to the divided end of the common iliac. We have found that this is more likely to succeed than an end-to-side anastomosis. At the lower end an end-to-side anastomosis is made with the common femoral. If it is decided to take the graft down to the popliteal artery, then an end-to-side anastomosis is made at the lower end as well but, in addition, a side-to-side anastomosis is made between the graft and the common femoral artery opposite the origin of the profunda femoris.

In our 38 aorto-iliac cases, there were 4 grafting procedures, with 1 death and no late closures; and 33 endarterectomies, amongst which there were 4 early failures and, up to date, no late closures.

#### *Anticoagulants*

It has been our policy to have the patient well heparinized during the course of the operation, and then deheparinized at the end of it. Usually on about the 2nd or 3rd post-operative day, oral anticoagulant therapy is commenced and this is continued indefinitely, the prothrombin level being controlled at regular intervals.

#### *Sympathectomy and Conservative Treatment*

A considerable number of patients seen at our clinic are not suitable for direct arterial surgery. In many the disease has progressed beyond the reasonable scope of direct surgery, while in others it has shown its effects in other regions of the body. Many cases give a history of a previous coronary thrombosis, but this does not necessarily preclude them from surgery. It is estimated that at least 75% of patients with symptoms of arterial insufficiency in their legs show clinical evidence of atherosclerotic heart disease. About 20% will have had a cerebrovascular accident, about 50% suffer from hypertension, and in addition there will be a considerable number who have serious renal impairment. Probably not more than about 12% of the patients can be expected to have no other clinical evidence of atherosclerotic disease.<sup>11</sup>

Conservative measures must therefore play an important part in the management of many cases, and many patients can be improved very considerably along such lines. Amongst

these measures, regular exercise is an important—indeed, an essential—part of the treatment. In our opinion, the vasodilator drugs have no place in the treatment of these cases; in fact they can do harm. We have used vitamin E quite extensively in large doses for a considerable period, but we are not impressed by its value. We find, on the other hand, that the anticoagulants have a definite place in the treatment of these cases, especially if they can be given over a prolonged period, and of course provided that the prothrombin level can be checked regularly.

In a few cases, sympathectomy still has a place in the treatment, not for the purpose of relieving intermittent claudication, but with a view to delaying the onset of ischaemic changes in the distal extremity. Where there is extensive occlusion of the aorto-iliac vessels in addition, we have found that the standard lumbar sympathectomy is inadequate, and in these cases we perform an extended sympathectomy, resecting the whole of the lumbar chain together with the lower 4 dorsal ganglia.

#### *Abdominal Aortic Aneurysms*

In the period under review, resections of aortic aneurysms with replacement by synthetic prostheses have increased to 26 cases. Another 26 cases of peripheral aneurysms have also been dealt with, in 2 of which—1 popliteal and 1 carotid—the defect was replaced by means of a vein graft.

Our indications for operation in abdominal aneurysms remains unchanged. Provided there are no other contra-indications to surgery, we consider that operation is indicated in every case presenting with symptoms from the aneurysm, including subjective awareness of pulsation in the abdomen. Needless to say, rupture or leaking of the aneurysm constitute an emergency. For the patient with an aneurysm of small size with no subjective symptoms, and who is able to report for regular routine checks, we continue to err on the conservative side.

Synthetic prostheses have been used in all our cases, woven teflon being the material in use since September 1958. Aortic homografts are generally considered to be inferior to the synthetic materials, being liable, as in the more distal vessels, to aneurysmal dilatation and early degenerative changes.<sup>2,7</sup>

#### *Extracranial Cerebral Vascular Disease*

Whereas, in the past, vasospasm was considered a possible cause of cerebral ischaemia, it is now well established that in many of these cases the ischaemia is due to disease of the carotid and vertebral arteries, in the extracranial part of their course. In the majority of cases, the narrowing is due to atherosclerosis, and it is stated that occlusion of this part of the carotid artery occurs as commonly as occlusion of the middle cerebral, and that occlusion of the vertebral artery in its cervical course occurs more frequently than occlusion of either the basilar or posterior inferior cerebellar artery.

An interesting observation is that in the case of the carotid, the atheromatous disease is frequently localized in the internal carotid artery at a point 1 cm. above its origin, while in the vertebral artery the lesion is confined to the portion lying between its origin from the subclavian and the vertebral canal.

It is not infrequent for haemorrhage to occur in the base of such a plaque and thus produce an acute episode of ischaemia.<sup>12</sup>

Between a third and a half of patients coming to autopsy cerebral infarction show advanced disease of the carotid and vertebral arteries in varying combinations. Commonly all 4 vessels are involved in stenosis or occlusion. Less commonly only the carotids are affected, and least commonly only the vertebrals.<sup>13</sup>

Much attention has in recent years been given to the syndrome of 'little strokes' defined by Alvarez,<sup>14</sup> in which transient episodes of neurological disturbance are often a prelude to a major cerebral catastrophe. Between these attacks the patient may be completely symptom-free or alternatively his attacks are superimposed on a state of gradually deteriorating neurological dysfunction. It is in this group of patients that at autopsy atheromatous stenosis is commonly found in the extracerebral vessels, and it is suggested that the transient attacks of ischaemia are caused by temporary failures of the collateral circulation, which in these cases must depend on the vertebral arteries and the carotid on the other side. It is clear that a degree of stenosis may be present for some time without producing symptoms of any kind, and that any illness producing a sudden hypotension may then precipitate an attack of cerebral ischaemia.

Surgical treatment for this condition has now become well established, and the results where the occlusion is incomplete are very good. Where it is complete the results are unsatisfactory, although Rob<sup>12</sup> feels that there is a place for disobliteration in an early case of complete occlusion before the thrombosis has had time to become adherent to the vessel wall. It is important in all these cases where direct surgery is contemplated to have all 4 arteries outlined by arteriography before a decision is made regarding ultimate treatment. It is felt that there is a very definite place for direct arterial surgery in the early case of stenosis of the carotid artery, even more so than there is in the case of the lower limbs.

#### SUMMARY

We are greatly impressed by the results of direct surgical procedures in the treatment of occlusive vascular disease affecting the lower limbs and the carotid arteries.

Whereas in the early stages of our series, it was mainly the well-advanced case of atherosclerosis that was considered for grafting or endarterectomy, we now take the view that there is a very definite place for this type of surgery in the early case.

Extremely good results can be expected in all patients presenting with a limited area of stenosis or occlusion, and this applies both to the carotid arteries and the large arteries supplying the lower limbs.

Once extensive disease has occluded the greater part of the aorto-iliac vessels, endarterectomy may still produce an excellent result, and this is always preferable to a grafting procedure.

Most of our femoral occlusions have been late cases,

in which endarterectomy is impossible, and a bypass graft has had to be inserted. Here the results, although quite dramatic in some cases, are on the whole not as good. Nevertheless, many of the patients are extremely pleased with the result; their claudication has either disappeared altogether or else it has been greatly improved. In a considerable proportion, of course, the grafting procedure has been a limb-saving operation.

All writers have experienced late closure in the grafts in a certain percentage of cases, no matter what the material employed, but this complication does not necessarily compromise the circulation to the limb, and in fact in many of these cases good results have followed a second and even a third grafting operation.

Because of the better long-term results following endarterectomy, we feel that this operation should be employed more frequently in the thigh but, in order for this to be possible, the patients must be seen at an earlier stage of their disease.

There is still a very definite place for sympathectomy in certain cases but, where the occlusion is at a high level, the sympathectomy must include at least the lower 3 or 4 dorsal ganglia.

A large percentage of patients must still be content with conservative measures, and there is no doubt that many are benefited very considerably by a carefully planned regime.

Direct arterial surgery is difficult surgery. Very careful assessment is required in every case, because not only are the various procedures liable to special complications, but most patients coming to surgery suffer in addition from other manifestations of their atherosclerotic disease.

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#### ADDENDUM

It is interesting to note that whereas during the 3-year period under review 45 cases of endarterectomy were performed, we have added another 43 during the first 5 months of this year. The 88 endarterectomy cases are split up as follows: Aorto-iliac 61, femoropopliteal 12, carotid 14, and renal 1.

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