W. T. IRVINE *ET AL.*: FEMORO-POPLITEAL ENDARTERECTOMY

FIG. 1a.—Pre-operative femoral arteriogram showing popliteal stenosis.

FIG. 2a.—Pre-operative lumbar aortogram showing external iliac, common femoral, and superficial femoral stenosis.

FIG. 2b.—Post-operative lumbar aortogram after endarterectomy and Dacron patch.

FIG. 1b.—Post-operative femoral arteriogram after endarterectomy and Dacron patch.

FIG. 1c.—Intimal core removed at operation.

In the first four groups the tendency of the neurological lesion was towards recovery, and the prognosis regarding life was usually good. The patients with distal sensorimotor polyneuropathy, however, all died with widespread vasculitis.

In most patients the neuropathy was thought to be due to occlusion of the vasa nervorum by the arterial disease sometimes associated with rheumatoid arthritis. This view was supported in our cases by clinical and histological evidence and by the finding, on brachial arteriography, of occlusive lesions in the digital vessels in the majority of instances. In a few patients the neuropathy was attributed to local pressure from a damaged or swollen joint. In others both pressure and vascular disease were thought to operate.

It is confirmed that patients with rheumatoid arthritis and ischaemic neuropathy have a positive differential agglutination titre and a high incidence of nodule formation. They often show evidence of vasculitis elsewhere. This is not necessarily so where pressure alone is the cause of the neuropathy.

Many of the patients were receiving steroids, but no clear evidence emerged that this therapy was directly related to the development of neuropathy.

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Femoro-popliteal Endarterectomy

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[WITH SPECIAL PLATE]

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With the introduction of endarterectomy for occlusive vascular disease it soon became apparent that such arterial reconstructions below the inguinal ligament were much less successful than similar procedures on the aorta and iliac arteries. This led to the introduction of the femoro-popliteal bypass grafts (Kunlin, 1951), and the end-to-side anastomosis allowed by this technique ensured longer anastomoses in these small arteries. There was a far higher primary success rate, but longer assessment has shown the life of cloth grafts below the inguinal ligament to be depressingly short, and adequate saphenous veins for use as grafts were often not present (Irvine, Kenyon, and Stiles, 1963). These late failures have led to the reintroduction of endarterectomy below the inguinal ligament. This has received added impetus from the introduction of arterial strippers which allowed long lengths of artery to be cleared through multiple short arteriotomy incisions, though many surgeons still prefer arterial clearance by open arteriotomy incisions (Edwards, 1962). The second technical advance which has improved the primary results of endarterectomy in small vessels has been the use of vein or Dacron patches at the time of closing the arteriotomy to avoid narrowing the lumen (Cannon, Barker, and Kawakami, 1958; Edwards, 1962).

This report deals with a group of patients having multiple or single endarterectomies below the inguinal ligament. Some of them had, at the same operation, extensive endarterectomy above the inguinal ligament.

Clinical Material

This paper is based on the study of 37 patients (35 male and 2 female), and reports the results of endarterectomy below the inguinal ligament in 38 limbs. All patients suffered from atherosclerosis, and had thrombosis or stenosis of the femoral or popliteal artery. In addition, some patients had thrombosis or stenosis of the aorto-iliac vessels. The mean age of the patients was 55 years. The incidence of related disease has been assessed with regard to those conditions that are known to be associated with peripheral arteriosclerosis. One patient suffered from diabetes; six of the 37 patients had E.C.G. changes of past myocardial ischaemia; 10 had a diastolic blood-pressure greater than 95 mm. Hg. Routine serum cholesterol estimations were carried out in all patients, and in 10 it was 300 mg. or more.

Selection of Patients.—The indications for operation in this series were intermittent claudication, rest pain, or gangrene. The distribution of patients in these groups is shown in the Table. In the majority of cases the claudication distance was 100 yards (90 metres) or less (80%), and in 16 of these the

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claudication distance was 50 yards (45 metres) or less. Four patients in this series had rest pain severe enough to interfere with sleep. Three cases had established gangrene of the toes.

Primary Indication for Operation

Intermittent claudication	...	...	...	31 (82%)
Claudication and rest pain	...	...	...	4 (10%)
Claudication, rest pain, and gangrene	...	...	...	3 (8%)

Clinical Findings and Investigations.—In those with occlusive disease localized to a short length of the superficial femoral or popliteal artery, the patient usually had a good femoral pulse with no pulses in the limb distally on the affected side. Occasionally, weak pedal pulses were present. Such patients were investigated by femoral arteriography. Where unequal femoral pulses were present, or bruits audible over the iliac or common femoral vessels suggested more proximal lesions, lumbar aortography was performed.

Operation

Type of Operation.—This report is limited to patients undergoing endarterectomy below the inguinal ligament. Of 38 limb operations in 37 patients, 16 were superficial femoral endarterectomies alone. Where the occluded segment was short, this was done through a single arteriotomy incision. In longer occlusions strippers with multiple arteriotomies were used. Eight patients had superficial femoral and popliteal occlusions, and both lesions were treated by endarterectomy at the same operation. Four had occlusions limited to the popliteal artery and were treated by endarterectomy; one had endarterectomy of the common femoral artery, and nine had aorto-iliac endarterectomy for proximal disease combined with endarterectomy below the inguinal ligament at the same operation. In 31 of the 38 endarterectomies below the inguinal ligament the arteriotomy was closed, using a vein or Dacron patch to enlarge the lumen. Figs. 1 and 2 (Special Plate) illustrate two typical operations.

Post-operative Course.—No immediate post-operative anticoagulants were used routinely. Most patients were given 500 ml. of Rheomacrodex during the first eight hours after return to the ward. Prior to discharge on the fourteenth day half of the patients were stabilized on phenindione, the dosage being adjusted to double the prothrombin time.

Operative Deaths.—There were no hospital deaths, and no subsequent deaths in the follow-up.

Operative Morbidity.—Six of the 38 limbs operated upon developed evidence of deep-vein thrombosis. In two patients wound infection led to infection of the patent arterial reconstruction with haemorrhage. Both had to be treated by proximal ligation, and this led to later amputation in both cases. One of these cases had infected gangrene prior to endarterectomy, but the other had presented with claudication alone at 100 yards (90 metres).

Primary Success of Endarterectomy

There was clear evidence by restoration of pulses that the endarterectomy remained patent in 36 out of 38 reconstructions (95%). As has been stated, two of these successes developed infection of their wounds which soon involved the arterial suture lines and required amputation. Of the two primary failures, errors in management are apparent in both in retrospect. The first had an endarterectomy of the middle third of the superficial femoral artery, and this failed. A femoro-popliteal vein bypass was inserted at a later date, and at this operation the common femoral artery was found to be very diseased, much more so than the arteriogram had suggested. This second operation was successful. The second primary failure was again after endarterectomy of the middle third

of the superficial femoral artery. Distal atheroma in the popliteal artery was ignored. The patient was made no worse by the primary failure, and a post-operative arteriogram showed thrombosis localized to the site of the endarterectomy.

Effect of Successful Reconstruction on Symptoms

The great majority of the 31 patients presenting with intermittent claudication alone had been advised surgery because of the severity of the claudication (25 stopped at 100 yards (90 metres) or less). All 29 primary successes in this group had complete relief from claudication after surgery. Five further patients had severe rest pain in addition to claudication, and in all five both symptoms were relieved. Two further patients presenting with toe gangrene had relief from their symptoms after operation. In one the toe healed after distal separation; the second had amputation of several toes at the time of the arterial reconstruction with primary healing.

Late Patency after Reconstruction

Of the 38 limbs in 37 patients, two were primary failures and two had later ligation of the artery above the reconstruction for wound sepsis. The Chart shows the present status of the cases available for follow-up.

There have been three late failures: one at six weeks, one at four and a half months, and one at five months. One of these had endarterectomy of the middle of the superficial femoral artery, ignoring some proximal disease in the common femoral artery above. This must be regarded as an error in management. The other two had very diseased distal popliteal vessels with poor calf vessels, and may have thrombosed owing to inadequate distal vasculature to take the increased arterial flow. There would seem to be no difference in late failure rate between those on anticoagulants and those not. However, the numbers are small and the follow-up is short, and differences may later appear between these two groups.

Discussion

Improvements in technique appear to allow endarterectomy to be performed below the inguinal ligament with a reasonable initial success rate. In this series it is 95%. If the occluded segment is of limited length this operation is preferred to the femoro-popliteal bypass graft. In practice, however, the arteriogram often gives an inadequate assessment of the length of artery requiring endarterectomy. This is frequently much longer than is apparent radiologically.

When the superficial femoral artery alone is the site of operation, the common femoral and popliteal arteries must be carefully scrutinized on the arteriograms. If any doubt exists about their adequacy they must be explored at operation, because disease above or below the superficial femoral endarterectomy may cause primary failure. When aorto-iliac occlusive disease is present in addition to disease below the inguinal ligament endarterectomy can be performed simultaneously above and below the inguinal ligament. In short occluded segments we prefer to use direct endarterectomy without stripping. In long occluded segments, if the atheromatous material separates easily, we use a stripper. Arteries are stripped under direct vision to ensure that no damage is done to the outer wall of the vessel, and any serious resistance to stripping requires a further arteriotomy. In all cases, whether stripping is done or not, the lowest limit of the endarterectomy is directly visualized through an arteriotomy, and the distal intima anchored where required.

We believe that any arteriotomy distal to the common femoral artery should be closed with a vein or Dacron patch, and some common femoral arteriotomies also require this. Some surgeons recommend arteriography on the operating-table, after stripping to ensure that no atheromatous fragments are left in the arterial lumen (Wylie, Binkley, and Albo, 1964). We have not practised this. It would certainly appear to be a wise precaution where stripping was difficult, but we prefer open endarterectomy under direct vision in these conditions.

The primary results have been encouraging, and all of those cases presenting with claudication were relieved of their symptoms. In the group of seven patients presenting with gangrene or rest pain the alternative to arterial reconstruction was a

major amputation, and all but one were saved this. The last patient would also have kept his limb, because his rest pain was relieved after a successful endarterectomy, had not wound infection reached the arterial suture line and haemorrhage from it necessitated proximal ligation and amputation. Against this salvage of six limbs must be set the loss of one limb in a claudicant where wound infection also required proximal ligation of a successful arterial reconstruction. These two cases emphasize the seriousness of wound infection in arterial operations, and in the limbs such infections almost invariably involve the arterial suture lines.

It remains to be seen whether long-term patency after endarterectomy below the inguinal ligament is superior to that seen after femoro-popliteal bypass graft.

Summary

The long-term results of cloth bypass grafts below the inguinal ligament have not been encouraging, and the calibre of the patients long saphenous vein is often inadequate. Improvements in technique have led to reintroduction of endarterectomy for superficial femoral and popliteal artery occlusions. This paper reports the results of femoro-popliteal endarterectomy for superficial femoral and popliteal artery formed by the open method or by using an intraluminal stripper, and the importance of using vein or Dacron patches to avoid narrowing the arteriotomy closure has been emphasized. The initial success rate was 94%. The importance of treating coexisting proximal or distal disease was stressed, and the primary and late results have been analysed.

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Studies with Complamin, a Nicotinic-acid-Theophylline Ester, as a Fibrinolytic Agent

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Though the feasibility of thrombolytic therapy with fibrinolytic enzymes has now been demonstrated—for example, Fletcher *et al.* (1959)—the expense involved in the preparation of suitable enzymes and the difficulties in laboratory control of enzyme therapy have stimulated a search for non-enzymatic agents which when administered might stimulate production or release of fibrinolytic enzymes in the body. One such substance is nicotinic acid, which, fibrinolytically inert *in vitro*, was discovered by Meneghini and Piccinini (1958) and Weiner *et al.* (1958) to have the property of inducing intense but transient fibrinolytic activity when injected intravenously in man. Because of the short duration of the fibrinolytic response and the rapid development of resistance, attempts have been made to provide modified preparations of nicotinic acid with enhanced activity, and it is the purpose of this paper to describe studies with one such preparation 3-(methyloxyethylamino)-2-

oxypropyl theophylline nicotinate—Complamin. The manufacturers of this preparation (J. A. Wulff, Düsseldorf) recommend it in the treatment of a very wide variety of vascular diseases, including acute peripheral vascular occlusion, thrombophlebitis, pulmonary and cerebral embolism, and myocardial infarction. Side-effects are said by the manufacturers to be "quite insignificant," and in particular freedom from side-effects on the circulatory system is claimed.

The fibrinolytic enzyme system is complex, but the main components are plasminogen, plasmin, activators, and inhibitors. Plasminogen, a normally inert plasma globulin, is converted by activators, themselves highly specific proteolytic enzymes, to plasmin, a proteolytic enzyme which under suitable circumstances digests fibrin, with release of soluble products.

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