



## The Treatment of Chronic Atherosclerotic Occlusion of the Lower Limbs – A Review of 30 Cases

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### Abstract

Atherosclerosis affects large elastic and muscular arteries, the most commonly and severely affected being the aorta. The cerebral, coronary, and renal arteries, and the arteries of the lower limbs are also frequently involved. The principal pathological changes are intimal thickening and fibrous tissue proliferation, which cause narrowing and occlusion. Ischaemia of tissues distal to points of obstruction occurs unless adequate collateral channels have had time to develop. Although atherosclerosis is a generalised disease, three main sites of occlusion in the lower limbs are recognised (Macpherson et al., 1971), the aortic bifurcation (aorto-iliac disease), the superficial femoral artery (femoro-popliteal), and more distant arteries (peripheral).

The purpose of this paper is to review the results of direct arterial surgery to the aorto-iliac vessels in a consecutive series of 30 patients and to correlate them with the indications for surgery and the nature of the lesions as determined by preoperative arteriography.

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ISSN: 2051-7580 (Online) ISSN: 0482-3206 (Print)

Res Medica is published by the Royal Medical Society, 5/5 Bristo Square, Edinburgh, EH8 9AL

Res Medica, Autumn 1974: 9-14

doi:[10.2218/resmedica.v0i0.911](https://doi.org/10.2218/resmedica.v0i0.911)

# THE TREATMENT OF CHRONIC ATHEROSCLEROTIC OCCLUSION OF THE LOWER LIMBS — A REVIEW OF 30 CASES

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## Introduction

Atherosclerosis affects large elastic and muscular arteries, the most commonly and severely affected being the aorta. The cerebral, coronary, and renal arteries, and the arteries of the lower limbs are also frequently involved. The principal pathological changes are intimal thickening and fibrous tissue proliferation, which cause narrowing and occlusion. Ischaemia of tissues distal to points of obstruction occurs unless adequate collateral channels have had time to develop. Although atherosclerosis is a generalised disease, three main sites of occlusion in the lower limbs are recognised (Macpherson et al., 1971), the aortic bifurcation (aorto-iliac disease), the superficial femoral artery (femoro-popliteal), and more distant arteries (peripheral).

The purpose of this paper is to review the results of direct arterial surgery to the aorto-iliac vessels in a consecutive series of 30 patients and to correlate them with the indications for surgery and the nature of the lesions as determined by pre-operative arteriography.

## Material and Methods

Direct arterial reconstructions were performed on 30 patients in the two year period January 1970 to December 1971. The period of follow-up was 1–2 years. All operations were for chronic atheromatous occlusion of the aorta and iliac arteries. The operations were:

Endarterectomy	(Total = 15)
(a) aortic	(2)
(b) aorto-iliac	(3)
(c) iliac	(10)
Prosthetic by-pass	(Total = 15)
(a) aortic 'Y' graft	(8)
(b) aorto-iliac (unilateral)	(2)
(c) aorto-femoral (unilateral)	(2)
(d) ilio-femoral (unilateral)	(3)

There were 23 males and 7 females. Nine males and 6 females were in the endarterectomy group and 14 males and 1 female in the by-pass group. All the patients were chronic cigarette smokers, 90% smoking 20 or more cigarettes a day.

## Age

The age groups of the patients are shown in figure 1. The youngest patient was 42 and the oldest was 65 at the time of operation. Both the range and distribution of ages are similar to those of occlusive vascular disease in general. The age distribution of the endarterectomy and by-pass groups differs slightly, the average ages being 51.6 years and 56.0 years respectively.

## Indications for Surgery

In cases of disease of the aorta and aortic bifurcation both lower limbs are threatened, although not necessarily to the same degree, and so symptoms may be expected in both limbs. In 22 patients the indication for operation was intermittent claudication in the buttock, thigh, or calf of one (20) or both (2) lower limbs severe enough to hinder the patient at work or getting to and from his work. The claudication distance was between 50 and 100 yards. Intermittent claudication was the indication for operation in 24 limbs and was a symptom but not the indication for operation in 5 other limbs (Table I). In 7 patients (7 limbs) the indication was rest pain with or without ischaemic lesions. As rest pain usually means that gangrene is imminent, this group is referred to as the "pre-gangrene" group. One patient was referred because of failure of a wound on the foot to heal and recurrent wound infection, and he has been included in this group. Four "pre-gangrene" patients suffered from intermittent claudication in the other limb. In one patient there was frank gangrene in one toe of one foot and intermittent claudication in the other leg.

Thus there were 23 asymptomatic and 37 symptomatic limbs, 29 with intermittent claudication, 7 with symptoms or signs of pre-gangrene, and 1 exhibiting frank gangrene.

## Associated Disease

The patients were investigated for any associated medical conditions, those of chief interest being hypertension, cardiac disease, and diabetes mellitus.

Hypertension was defined as a recorded diastolic blood pressure consistently greater than 100 mm Hg. It was present in 7 patients, 4 in the endarterectomy group and 3 in the by-pass group. The term "cardiac disease" includes patients with ECG abnormalities or a history of myocardial infarction, and patients with controlled cardiac failure. It was found in 4 patients. Diabetes mellitus was found in only 2 patients and in both the presenting symptom was intermittent claudication.

### Patterns of Occlusion

The pattern of arterial occlusions is the principal factor determining (a) the feasibility of surgery and (b) the possible operative procedure. To establish the patterns of occlusion pre-operative arteriography was performed on all patients, by either direct translumbar puncture of the aorta, or retrograde catheterisation of the femoral artery of the asymptomatic limb. The occlusions were classed as either single or multiple (Table II). There were 3 single occlusions involving the aorta and common iliac artery on one side, 8 involving one common iliac artery alone, and 1 involving one external iliac artery. These 12 were treated by endarterectomy. Two single occlusions of the external iliac and common femoral arteries were treated with ilio-femoral by-pass procedures. Multiple occlusions were classified as unilateral or bilateral; these were further divided into "aortic" and "non-aortic" depending on the presence of occlusions in the aorta, iliac and femoral vessels, or the iliac and femoral vessels alone. There were 6 multiple unilateral occlusions, 2 involving the aorta, and 10 multiple bilateral occlusions of which 8 involved the aorta. Thirteen of the 16 multiple occlusions were treated with prosthetic by-passes.

### Operative Procedure

The aim of direct arterial surgery is to maintain the artery's essential function of transmitting blood at an adequate rate. The selection of the procedure depended more on the type of occlusion and the state of the vessel wall above and below it than on the actual vessel involved. Each operation was designed for the individual patient. Endarterectomy was the procedure of choice in cases of short, usually single occlusions with good proximal and distal vessel wall (Table II). These conditions were more often found in younger patients (figure 1). Endarterectomy is easier to perform in younger patients, as they usually have a non-calcified and rubbery type of disease which enables a plane of cleavage to be found (Cannon, 1965). Of the 15 endarterec-

tomies only one was done bilaterally and this was for multiple occlusions at the aortic bifurcation. Prosthetic by-pass operations were performed when occlusions were long or multiple. The prostheses used were all of the crimped, woven Terylene variety, these having the advantage over the knitted grafts of less initial leakage after proximal and distal clamps are released (Rains, 1965). Crimping of the grafts enables them to be bent without the lumen becoming occluded. The synthetic fibres of the prosthesis remain unchanged as the intermediate layer of a vascular tube. A layer of dense fibro-cellular tissue surrounds the prosthesis and penetrates between the fibres to form a "pseudo-intima". This becomes lined on the inner surface by endothelial cells, though probably only in short implants is the lining complete (Macpherson and Muir, 1963). In 8 patients aortic bifurcated 'Y' prostheses were used, the upper anastomosis being to the aorta and the lower limbs being anastomosed to the common iliac (2), the external iliac (2), and the femoral arteries (4).

In 5 by-pass operations local endarterectomy was performed at sites of anastomosis. Sympathectomy was carried out in conjunction with direct operation in 5 patients in whom it was known that there were also distal occlusions, so as to combine an increased head of pressure proximally with maximum dilatation of peripheral vessels.

### Results

Patients were reviewed for 1-2 years after operation. There were no deaths in the series within the period of reviews

Clinical assessment was based on five criteria:

- (a) exercise tolerance
- (b) ankle oscillometry
- (c) pulses in the limb
- (d) skin temperature of the limb
- (e) improvement of symptoms

Ankle oscillometry was done before and after operation in 26 patients and an increase of 0.5 units was accepted as an improvement.

Improvement in four or five of the above indices was taken as evidence of continued patency of the artery or prosthesis and is classified as a 'good' result. If there was symptomatic improvement without definite objective evidence of improvement or only minor amputation was required, then the patient's condition is said to be 'improved'. 'Failure' indicates subsequent major amputation or re-exploration, or where there was neither subjective or objective improvement.

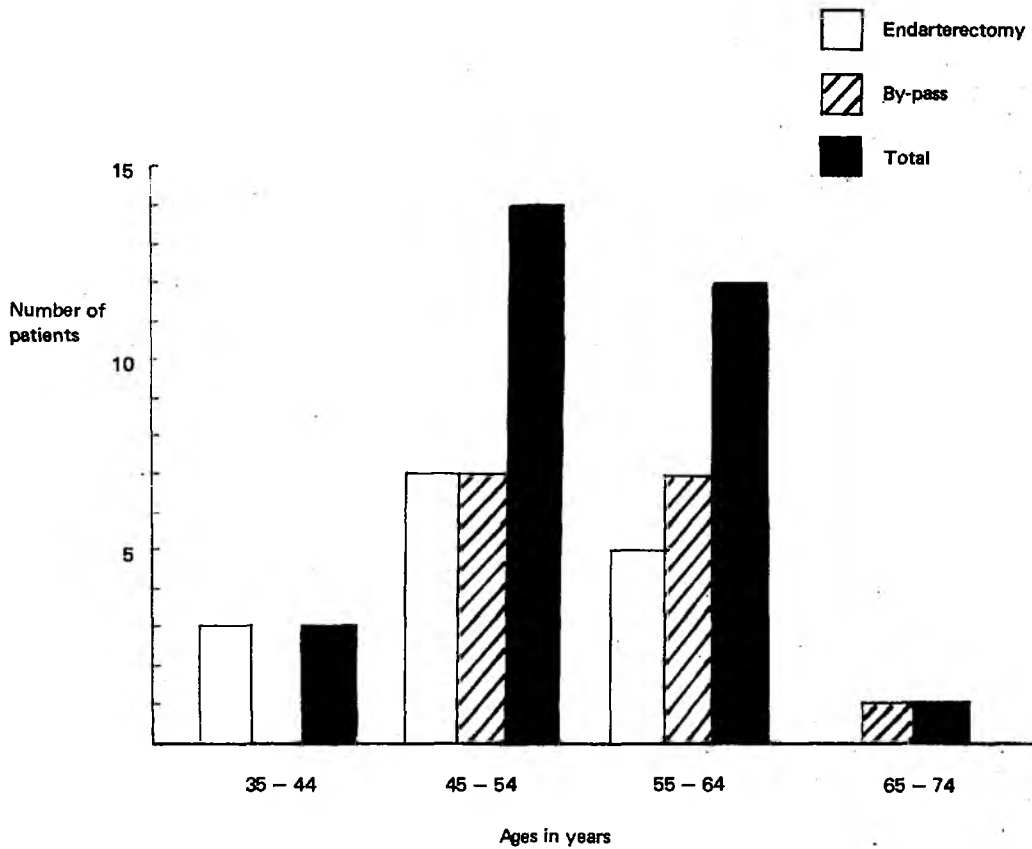


Figure 1 – Ages of patients submitted to surgery

TABLE I – Indications for Operation

Indication for Operation	Symptom in Other Limb	Endarterectomy	By-Pass
IC	AS	14	6
	IC	—	2
PG	AS	—	3
	IC	1	3
	PG	—	—
FG	AS	—	—
	IC	—	1
	PG	—	—
	FG	—	—

AS = Asymptomatic limb  
 IC = Intermittent claudication  
 PG = Pre-gangrene  
 FG = Frank gangrene

The results at the time of post-operative review are shown in Tables III and IV. Results are expressed in terms of limbs because procedures involving arteries of both lower limbs may produce different results in each limb.

Following endarterectomy there were 13 good results in 16 limbs and 2 were subjectively improved. There was only one failure. After by-pass procedures 17 of 21 showed a good result, 1 was improved, and 3 were failures.

Post-operative complications occurred in 17 patients (Table V). However, most were minor and there was no instance of infection of the prosthesis.

## Discussion

Over the 2 year period 30 patients with chronic occlusive vascular disease of the aorto-iliac region were treated by endarterectomy or prosthetic by-pass procedures with no post-operative mortality. In several larger series the mortality rates for similar operations have varied between 0 and 11% (Healey, 1964). The mortality rate is dependent upon many factors, in particular the selection of patients for operation. The importance of careful selection for reconstructive arterial surgery has been emphasised (Macpherson, 1970). Reconstructive vascular surgery has perhaps most to offer to patients whose limbs are in danger, but it is these patients who are most likely to have established coronary disease or generalised conditions causing decreased efficiency of the cardio-vascular system. With the inclusion of such patients mortality and morbidity rates may be expected to rise. In this series 12 patients had associated diseases likely to prejudice the outcome of surgery, but as a group their results were as good as those of patients without these conditions.

In Table VI the pattern of occlusions is correlated with the results of operation. It is evident that where there was only a single occlusion the results of direct arterial surgery were in general good, regardless of the site of occlusion or the method of treatment.

There were 4 failures in the series. All of these were multiple occlusions and 3 were bilateral. In the only unsuccessful endarterectomy the indication was intermittent claudication in one limb due to multiple occlusions in the iliac and femoral arteries. Three months after the original procedure ilio-femoral by-pass was performed and this was entirely successful. This second operation is not included in this series as it was done after the period of review. In 2 of the 3 by-pass failures the indication was intermittent claudication in one limb, and pre-operative arteriography showed

multiple bilateral occlusions involving the aorta and both iliac systems and a poor run-off in peripheral vessels. 'Y' graft procedures were, therefore, necessary and in one case bilateral sympathectomy was also done. There was no change in either subjective or objective indices after operation, but there was no subsequent deterioration in either the symptomatic or the asymptomatic limbs. The third by-pass failure was in a hypertensive man who had frank gangrene in one toe and rest pain in the calf on the right side and intermittent claudication on the left. Arteriography revealed multiple bilateral occlusions of arteries below the aortic bifurcation. The left side benefited and had a good result. On the right side the operation did not prevent the spread of gangrene to the mid-calf and a through-knee amputation was performed on the 9th post-operative day. The patient made a good recovery from the second operation and was well and active when last reviewed. The original operation was complicated by reaction to incompatible blood transfusion, acute renal failure and a respiratory tract infection.

In the one improved case the indication for the aorto-femoral by-pass was rest pain in the foot and calf of one side. Subsequent amputation of 4 toes for gangrene was necessary, but there was otherwise complete relief of symptoms. Thus multiplicity of occlusions and a bilateral distribution are two factors which adversely affect the results of direct arterial surgery.

Another factor that may influence the outcome of direct surgery to the aorta and iliac arteries is the presence of occlusions in more peripheral vessels. In 26 of the 37 symptomatic limbs it was possible to assess the run-off in the peripheral vessels by pre-operative arteriography. Eight had a patent superficial femoral artery with good filling of the popliteal artery and all had a good result from direct operation. In 10 limbs the superficial femoral artery was blocked, but the popliteal artery filled well from collaterals from a patent profunda. Nine of these had a good result. In 8 cases where there was poor peripheral run-off with minimal or no filling of the popliteal artery from collaterals, indicating occlusion of the profunda, 3 were failures, 1 was improved and 4 had good results. Harris (1968) states that a profunda circulation with a good head of pressure is sufficient to maintain viability of the lower limb. In the good and improved results a profunda circulation sufficient to keep the limb viable was achieved by increasing the head of pressure in the artery by successful reconstruction of the aorta and iliac arteries. In the 3 cases of failure the femoro-popliteal disease was severe enough to warrant treatment on its own merits. These 3 cases

**TABLE II – Types of Arterial Occlusions and Methods of Treatment**

Type of Occlusion	Site of Occlusion	Number of Cases	
		Endarterectomy	By-Pass
Single	Aorto-Iliac	3 (3)*	—
Single	Common Iliac	8 (8)	—
Single	External Iliac	1 (1)	—
Single	External Iliac & Common Femoral	—	2 (2)
Multiple Unilateral	Aortic	—	2 (4)
	Non-Aortic	2 (2)	2 (2)
Multiple Bilateral	Aortic	1 (2)	7 (11)
	Non-Aortic	—	2 (2)
		15 (16)	15 (21)

\* The figures in brackets indicate the number of limbs.

**TABLE III – Correlation of Pre-operative Symptoms in limbs with the Results of Endarterectomy**

Symptom	Number of Limbs	Result		
		Good	Improved	Failure
AS	14	—	—	—
IC	15	12	2	1
PG	1	1	—	—
FG	—	—	—	—

AS = Asymptomatic limb  
 IC = Intermittent claudication  
 PG = Pre-gangrene  
 FG = Frank gangrene

**TABLE IV – Correlation of pre-operative Symptoms in limbs with the Results of Prosthetic By-pass Procedures**

Symptom	Number of Limbs	Result		
		Good	Improved	Failure
AS	9	—	—	—
IC	14	12	—	2
PG	6	5	1	—
FG	1	—	—	1

AS = Asymptomatic limb  
 IC = Intermittent claudication  
 PG = Pre-gangrene  
 FG = Frank gangrene

**TABLE V – Post-operative Complications**

Complication	Number of Cases
Respiratory Tract Infection	12 a b*
Urinary Tract Infection	3 a
Wound Infection	3 a c
Acute Renal Failure	1 b
C.V.A.	1 c
Incompatible Blood Transfusion	1 b
Jaundice Following Halothane Anaesthetic	1

\* a, b, c = occurred in the same patients.

**TABLE VI – Types of Arterial Occlusions Correlated with the Results of Operation**

Type of Occlusion	Site of Occlusion	Number of Limbs	Result		
			Good	Improved	Failure
Single	Aorto-Iliac	3	3	—	—
Single	Common Iliac	8	8	—	—
Single	External Iliac	1	—	1	—
Single	External Iliac & Common Femoral	2	2	—	—
Multiple Unilateral	Aortic	4	4	—	—
	Non-Aortic	4	2	1	1
Multiple Bilateral	Aortic	13	11	—	2
	Non-Aortic	2	1	—	1
		37	31	2	4

had multiple bilateral occlusions in the large arteries of the pelvis, and when this type of lesion can be demonstrated it is likely that there are also occlusions in the more peripheral arteries of the lower limbs.

Arteriography can be misleading in the pre-operative assessment of the extent of disease and the choice of procedure. Arterial calcification should be demonstrated by vascular survey before contrast studies are attempted. When X-ray films are taken in one plane only, anterior and posterior atheromatous plaques may not be obvious and lateral view may then be of great help to the surgeon. On routine antero-posterior arteriography films the origin of the profunda artery is frequently not well visualised, and in this situation oblique films are often required.

The importance of demonstrating the whole arterial system of the lower limbs has been emphasised. When attempting to show intra-arterial lesions in the distal parts of the limbs trans-lumbar aortography has the disadvantage that the contrast medium is injected a considerable distance from the vessels being defined. As flow through diseased arteries is slow the medium is frequently dispersed through other channels before it has time to reach the distal vessels. Thus, the nearer the initial bolus of contrast medium is to the area being investigated the more successful the investigation is likely to be. This may be achieved by direct puncture of the common femoral artery on the affected side if the femoral pulse is palpable. The complications of femoral artery puncture for diagnostic procedures have been reported by Bouhoutsos and Morris (1973). They found that atherosclerosis was not an important predisposing factor in the causation of thrombosis following arterial puncture, but that if thrombosis did occur in the atherosclerotic patient he was at great risk of the thrombus propagating distally with subsequent loss of the limb.

## Summary

Thirty patients with chronic atherosclerotic occlusion of the lower limbs treated by direct surgery to the aorta and iliac arteries have been reviewed. There was no post-operative mortality. The patency rate was 93.7% for endarterectomy and 86.3% for prosthetic by-pass procedures. Indications and results have been expressed in terms of the number of limbs involved rather than the number of patients as this gives a more accurate analysis of the outcome of surgery. The type and length of the occlusions were the

principal factors determining the operative procedure. If the occlusions were short and usually single, then endarterectomy was the operation of choice; if the occlusions were long and multiple, then a prosthetic by-pass procedure was preferred. The important factors affecting the outcome of reconstructive arterial surgery are the selection of patients, the distribution and multiplicity of arterial occlusions, and the state of the vascular tree distal to them and in particular the patency of the profunda femoris.

## Acknowledgements

All patients were treated by Mr A.I.S. Macpherson at the Royal Infirmary, Edinburgh. I would like to thank Mr Macpherson for allowing me to review his patients, and for his advice and criticism of this paper.

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